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Previous publications of The Michigan Academy of Science, now known as The Michigan Academy of Science, Arts and Letters, were issued under the title, Annual Report of the Michigan Academy of Science. Twenty-two volumes were published, of which those numbered 1, 21 and 22 are out of print. Copies of the other volumes are still available for distribution and will be sent on exchange so long as the editions last. Applications for copies should be addressed to the Librarian of the University of Michigan.

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MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

VOLUME X

CONTAINING PAPERS SUBMITTED AT THE ANNUAL MEETING IN 1928

(The papers in Botany and Forestry of the 1928 meeting appear in Volume IX.)

PAPERS

OF THE

MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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Set up and printed,
March, 1929
Published, April, 1929

PRINTED IN THE UNITED STATES OF AMERICA

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COLOR NOMENCLATURE IN BATAK AND MALAY*

HARLEY HARRIS BARTLETT

Introduction
Method of inquiry
Color vocabulary of the Malay of Batoe Bara
Relationships of the Malay color words
Summary for Malay
Javanese color words
Color vocabulary of the Pardembanan dialect of Batak
Relationships of the three characteristic Pardembanan color words
Discrimination of colors by the Pardembanan Batak
Color vocabulary of Toba Batak:
1. Upper Koealoe
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Relationships of the characteristic Karo color words
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INTRODUCTION

THE Indonesian languages quite generally lack separate words for green and blue. This peculiarity has been noticed by the compilers of many vocabularies and by other writers. Warneck,[1] one of the leading authorities on the Batak of Sumatra, goes much too far in saying that the Batak have no sense of color, but equally

* Paper from the Department of Botany of the University of Michigan, No. 286. (Presented by title at the 1927 meeting of the Academy.)

[1] "*birong*, schwarz, dunkel (da die Batak keinen Farbensinn haben, und darum die meisten Worte für Farben fehlen, so bedeutet *birong* jede dunkle Schattierung: z.B. der tief blaue Himmel oder der blaue See wird so bezeichnet)." — Warneck, J., *Tobabataksch-Deutsches Wörterbuch*. Batavia, 1906.

decided statements about other Malayan peoples are often made by Europeans.

It is believed that the present paper contains the second reasonably thorough study of color nomenclature that has been made in the Indonesian region proper, the other being that of Maas (41). At the time of making his observations the writer felt sufficiently acquainted with the literature on the Malayan region to be sure that the study, imperfect though it might be, would not be superfluous. Since then his attention has been called to the admirable study of color vision and nomenclature carried out by Rivers (53) among the Papuans of Torres Straits, which, undertaken as it was by a psychologist using better methods, is in some respects far more detailed and valuable than the present one. It may consulted by the reader for references to literature concerning color-blindness, etc., which is not reviewed here. Rivers found evidence that a defect in color nomenclature in a given dialect may possibly be associated with defective sensibility among the speakers of that dialect for the color concerned. His work, therefore, supports to a considerable extent the view of Magnus, who accumulated evidence from living races of man showing that many native languages were deficient in color words, and indicating that the defects must have a physiological basis. Bastian (5) had pointed the way for Magnus's work in a brief comment on the evidence that aboriginal languages might contribute to prove or disprove Geiger's hypothesis that in the dawn of civilization words for blue were probably not used. Geiger had shown the absence of original words for blue in the Vedas, the Zend-Avesta, the Bible, and in Homer, pointing out that sometimes the words used for blue originally meant green, but that predominantly the earliest ones had meant black. Prior to the studies of Geiger, Gladstone had drawn conclusions as to primitive color perception from the poverty of the color vocabulary in Homer. The views of Geiger and Magnus were supported by Richard Andree (2) who concluded, after a review of many languages of Asia, Africa and America: (*a*) that sky-blue is a color recognized by various aboriginal peoples; (*b*) that numerous primitive peoples of Asia, America, Africa and the South Seas use a single word for black, blue and green, for blue

and green, for black and blue, or for green and blue, so that in fact these several color associations appear to them as single colors; (*c*) that other ethnically and geographically widely separated peoples do not distinguish red and yellow, and sometimes white, by separate words; (*d*) that there are color-poor primitive peoples who have only two designations for color, one for the "dark" colors (black, with blue and green) and one for the "light" colors (red and yellow), so that in extreme cases Geiger's law seems to hold that as we approach the primitive the failure to differentiate the middle colors increases, until at last only black and red remain; (*e*) that on the contrary there are primitive people with keen sense of color who discriminate the whole scale of colors and their intermediates.

The Malayan peoples are capable of making finer color discriminations than they generally do when not subject to outside influence. This is shown by the fact that European contact results in an enrichment of the color vocabulary, such as we find in Tagalog and Malay. Not all speakers are able to use the borrowed terms with any degree of precision, however, so that even with words available for expressing the differences, there remains much confusion of blue with green, of blue with black, of violet and purple with red or brown, and the like. It is of course true that colors may be and sometimes are designated by comparisons, and that the Indonesian languages are therefore, as Brandstetter (11) properly insists, capable of greater precision than the vocabularies would indicate. The following lists will show, however, that comparisons when made are often vague and inaccurate, as, for example, the comparison of brown with the rose-purple flower of Melastoma,which occurs in the lists.

The search of published dictionaries and vocabularies often gives a false impression regarding the richness of the color nomenclature. Very rare words are often recorded which are practically never encountered in actual speech. The dictionary does not often indicate whether a word is rare or common. In the writer's experience very rare words are used with the least precision. Thus in Batak the word *rah*, identical with Old Javanese for blood, was said to be a color word, but only a single man mentioned it in reply

to a request to identify colors and he said it meant green. Others knew the word, but were too hazy in their ideas of what it meant to deny that it meant green.

Turning now specifically to the Batak, the writer found that, among those who use a single word for blue and green, there are some individuals who are clearly able to distinguish the two colors but have no word for blue. Others, when shown several samples of blue and green, are apparently quite unable to tell which are green (i.e., like the leaves of the trees) and which blue (like the sky). The latter persons would frequently group the blue and green samples by shade or tint as dark (*toewa*) or light (*moeda* or *na poso*), ignoring the actual color altogether.

Natives questioned by the writer were frequently embarrassed by not being able to give names for different hues which they promptly agreed were different when the fact was pointed out to them. In such cases they often resorted to verbal evasions. Since nearly all the Batak know more or less Malay, they would apply the Malay word to one hue and their own dialect word to another. For example, if shown Indian red and rose madder, the speakers of the Pardembanan dialect in Asahan would call the first color that they saw *na gerger* and the second *merah*. Likewise, if they were able to distinguish blue and green, they might call whichever color they first saw *na rata*, the familiar Batak word for green, and the other *idjo*, the Malay for green. If they were again shown the colors in reverse order, the application of the names would often be reversed by the same informants, showing that they were merely bringing in every word they knew in order to have enough different names to go around.

Dark colors gave especial difficulty, and names were supplied by another type of evasion. In this case true color names were often not given at all, but the color was described as "faded," "dyed," "dull," or "splotched." There will be many examples in the detailed notes which follow.

Malays use similar vague terms, which might be mistaken for color words of definite meaning if one referred only to an English-Malay vocabulary. For example, *sokom* is given as Malay for tan-colored or yellow with the parenthetical qualification "of dogs."

The suspicion at once arises that *sokom* used only "of dogs" is not a true color word and has been treated badly by the lexicologist. This suspicion is confirmed when one looks up the word white, and finds "*sokom*, clouded white (of dogs)," or gray, and is again confronted by "*sokom*, gray (of dogs)."

METHOD OF INQUIRY

The writer started making color records in an unsystematic way, without any idea of doing more than was necessary to understand what the natives meant by the color words they used in describing flowers and plants. Wide stripes were painted in water color across sheets of paper which were then cut lengthwise so as to provide test strips of convenient width for recording directly on the strips a single set of answers. Since at first there was no intention of making many inquiries, only a few test strips were prepared. Subsequent lots were made as needed, which varied considerably in the number and variety of hues presented for identification. There was not the slightest evidence, however, that color discrimination was ever so keen that the lack of uniformity in the tests made any difference at all. The results of the Pardembanan inquiries (which were made first) were so interesting that they were extended, as opportunity offered, to Toba Batak as spoken in Upper Koealoe, Habinsaran, and the vicinity of Toba Lake, and to Karo Batak. There are many other dialects in North Sumatra for which no records were obtained. A few records were made in the Simeloengoen district bordering on Asahan, but the people questioned were all of Pardembanan origin and did not speak the true Simeloengoen dialect, so their replies were thrown in with the Pardembanan of Asahan. The inquiries were all made within a few miles of the Soengei Silo Toewa, which forms the boundary between Asahan and Simeloengoen.

The method of procedure in making a record was not uniform, and could not easily be made so. Whenever possible, a single person was questioned, and his replies were of necessity independent. More often, however, a little group, as, for example, the people congregated about a house ladder or working in a *ladang*, or a small group calling at my camp, would be questioned. The most talka-

tive of a group would be asked the names of the colors, and the replies were attributed to him or to her in the record even if the spokesman consulted or argued with the rest before giving a reply. The answers might be his or her own except for the acceptance of a suggestion or two, or might represent the consensus of opinion of several people, sometimes a dozen or more. If there was a definite divergence of opinion, another spokesman's replies would be recorded, if possible.

The writer's questions were generally put in Malay but the answers were asked for and given in Batak. The writer could speak the Toba dialects only very slightly and generally had assistance from Bataks who spoke both their own tongue and Malay. In Karoland the writer was quite dependent upon a very intelligent Malay-speaking Karo. Answers to questions were written on the test strip in the Batak character so that the informant, if he could read, might check the record. The novelty of a foreigner writing their character nearly always proved a sufficient stimulus to keep the informants interested in answering the questions. As a matter of fact, the Batak and Malay enjoy talking to a stranger, and nearly always show interest in teaching a few words of their language.

All the test strips were made on the same kind of paper. Since the paper modifies colors slightly unless pure white and free of chemicals, the resulting colors were matched as closely as possible with Ridgway's standards (52) and Ridgway's nomenclature is used in the lists that follow. The tone of the same pigment varied slightly from strip to strip, depending upon the dilution, but the variation was too little to influence my own designation of the colors, unless they were compared with the standards, and the informants were quite regardless of such minor distinctions. The colors used were matched with grenadine red, Indian red, Eugenia red, rose, brown madder, carrot red, cadmium orange, Mars orange, Van Dyke brown, a tint between light cadmium yellow and lemon chrome (called merely yellow in the lists), yellow ocher, lemon yellow, yellowish oil green, deep malachite green, spectrum blue, Payne's gray, indigo (this name is not in Ridgway, nor is the color, but the pigment is that so labelled by Winsor and Newton), amethyst violet, and violet slate. In some cases where colors were

not discriminated in any way, as, for example, yellow ocher, lemon yellow, and light cadmium yellow, the answers are all stated under yellow.

COLOR VOCABULARY OF THE MALAY OF BATOE BARA

Since the medium of communication between the Batak and outsiders is usually Malay, which is now used by some of the Batak near the coast almost or quite to the exclusion of their own language, it was desirable to determine the local application of common color words in as pure a Malay as possible. Instead of making inquiries from the medley of Malay-speakers who have come into Batak territory relatively recently from various localities, the Malay records were all made in Batoe Bara, a small coastal district at the north of the present Asahan, where the original Malay population came long ago from Minangkabau. Subsequently many Peninsular, Bornean, and other Malays have been absorbed into the population, as well as many Pardembanan and Simeloengoen slaves, but the predominant tongue is, and probably has been for centuries, Malay. The people are mostly fairly well-to-do and intelligent. Seven individuals or groups were questioned, with answers as follows:

Indian red
- merah toewa, old (i.e., dark) red
- merah moeda, young (i.e., light) red
- satengah merah, half red, (i.e., reddish)
- tjokolat merah, red-brown
- tjokolat moeda, light brown

carrot red
- merah moeda, light red
- djinggo; the usual word for dark yellow, orange or ruby red in Standard Malay is *djingga*

grenadine red
- merah toewa, dark red

rose
- merah djamboe, red of the *djamboe* fruit, (i.e., a true rose)
- merah, red
- merah paroe-paroe, red of the lungs
- merah tĕroes, straight (i.e., true) red
- tjokolat merah, red-brown

brown madder
- kĕlaboe, ash-colored

lemon chrome
- koening moeda, light yellow
- koening, yellow

yellow ocher
- koening, yellow
- koening toewa, dark yellow
- koening moeda, light yellow
- idjo moeda, light green

Mars orange
- tjokolat moeda, light brown
- djinggo; *djingga* (Stand. Mal.) is orange or ruby red
- koening moeda, light yellow
- merah, red
- merah moeda, light red
- paroe-paroe, lung-colored

Van Dyke brown
- tjokolat, brown
- tjokolat toewa, dark brown

Van Dyke brown (continued)
satengah koening, half yellow, (i.e., yellowish)
merah tjokolat, brown-red
malachite green
idjo or idjau, green
yellowish oil green
idjo or idjau, green
poetjo pisang, (color of) banana shoot
biroe, blue
spectrum blue
biroe, blue
idjo or idjau, green in modern Stand. Mal., but the primitive word for both blue and green
oengoe moeda, light violet
Payne's gray
oengoe or ongo, violet
kĕlaboe, ash-colored
itam moeda, light black
biroe, blue
idjo ajer laoet, green of sea water
bĕlaoe, blue
indigo
itam moeda, light black
biroe toewa, dark blue
biroe boenga taroem, blue of the indigo plant
oengoe or ongo, violet
amethyst violet
oengoe or ongo, violet
idjo moeda, light green[2]
tjokolat idjo, green-brown
black
itam, black
oengoe, violet
white
poetih, white

RELATIONSHIPS OF THE MALAY COLOR WORDS

MERAH, *red* — The principal word for red in Malay is likewise found in Minangkabau and Gajo. The root *rah* is probably the same as in Mal. *darah*, blood, and means red. It is found also in Minangkabau *sirah*, red. It is difficult, however, to make out the lineage of the long series of words, extending from the Mon-Khmer languages of Asia to the limits of Polynesia, which appear to contain roots identical in origin with *rah* and express ideas ranging from red to blood in one direction and from red to heat and dryness in another. It is not impossible that the primary meaning of the root was sun. The matter is discussed under Toba *rara, gara, bara* (p. 28). There are also words for red which seem to be related to the words for charcoal, and are discussed under Toba *birong* (p. 33). One of them is Mal. *merang*, which might be interpreted as a phonetic modification of *merah*, or vice versa. Both consist of an adjectival formative plus a second element which is clearly *rah* in *merah*, but may be *erang*, a red-hot coal, in *merang*. *Merang* is the color of

[2] In this translation the writer has perhaps unfairly emphasized the restricted modern meaning of *idjo* as "green" among educated Malays. The reader must bear in mind that *idjo* as used by ordinary people applies to the color range from green to blue.

the ripened crop or of vegetation parched by the sun. Wilkinson (71) says "bright red, fiery red." Dempwolff (22) refers to Original Austronesian *irah*, to be red, without indicating specifically what words he believes to be derivatives. It is by no means inconceivable that charcoal got its name from the word for red, and that such words as Mal. and Jav. *merang* and Bisayan *magang* ("color encarnado muy vivo") are immediate cognates of Mal. *merah*.

DJINGGO, *carrot red, orange* — This word was always pronounced with final *o* in Batoe Bara, evidence of the Minangkabau origin of the speakers, and never with final *a* as in Peninsular Malay. It has not been traced beyond Malay, and the fundamental meaning is unknown, but it may be composed of the roots *sing* and *ra*, both meaning sun or red.[3]

TJOKOLAT, *brown, Indian red* — This word immediately strikes one as borrowed from Dutch or English — our word chocolate. The word occurs in the Malay dictionaries as *tjoklat* or *choklat*, which might better have been written *tjokĕlat*. (The *ĕ* becomes *o* under either Minangkabau or Toba influence.) The writer has not heard it pronounced by any native except as distinctly trisyllabic. The easy acceptance of the word by the Batak and Malay seems to have come about through accidental verbal similarities which are discussed under Pardembanan *kolat, si kolat, masam kolat* (p. 19).

KĔLABOE, *gray, brown madder* — The primary meaning of

[3] In this connection it would be interesting to have the full evidence from which Dempwolff decides that *tjinar*, shining red (I transpose his phonetic spelling into the usual Dutch spelling), is Original Austronesian. *Tjinar* is obviously Malay *sinar*, in which I have tried to recognize a root *sing* (see note on Karo *gĕrsing*, p. 41). *Tjin* is an easy intermediate between *djing* and *sing*. Furthermore, there is a Karo phrase *djingar garana*, flaming-up of the firebrands, in which the word *djingar* seems equivalent and cognate with Mal. *sinar*. It is explained by Joustra (33) as a figurative use of a word which means rakish or foppish. The connection is hard to see, and it would seem more likely that there is a confusion of words of entirely distinct origin but of the same form. It may be remarked that Karo provides another example of the second meaning of the root *djing* in the reduplicated form *djingdjing*, which means to wear the clothing too high, so that more of the leg is exposed than is conventional. This is exactly the Malay *singsing*, in origin and meaning, for Karo has the form *singsing* also. As noted under the discussion of *gĕrsing*, there is confusion of the Malay words also, one meaning of *singsing* being the first light of morning.

kĕlaboe is ashy, the word being derived from *kaboe* (= *aboe*), ashy, by infixation of the adjectival formative *ĕl*. With the same or a different formative, or unmodified, a cognate word for gray runs through many languages. *Aboe*, ash, is Original and Common Indonesian,[4] and may be traced into adjoining linguistic areas. Schmidt (59) identifies Stieng (Mon-Khmer) *nbūh* with it, and Kern (37) finds it in Fiji, as *dravu*. Favorlang (Formosa) has *abo* (13) and Chamorro *apo* (67). In Celebes, Tonsea has *dawu*, the base of *kidawuan*, and Makassar *awu*. Dayak has *kawo*, Javanese *awu*, and a long list of other island languages have easily recognized equivalents, many of which are listed by Wallace (69). It is less common for adjectives to be recorded in vocabularies than substantives, but nevertheless a representative group of languages may be shown to have a word for gray which is derived from a cognate of *abu*, by one or another method of word formation. Thus, Karo *mĕkĕlaboe* and Gajo *kĕlaboe* from *aboe*, although in both languages *aboe* itself has undergone modification, Gajo having *waoe* and *öböm* and Karo *aboeng* and *abam*. Atjehnese has *kĕlabée* from *abée;* Minangkabau *kalaboe* as well as *aboe-aboe* by reduplication; Tontemboan *awu-awun;* Fiji *dravu-dravu*. Malagasy has *mavo*, according to Brandstetter (9) *m* + *avo;* it means not only gray but also brown (Malzac, 42) and the simple word base meaning ashes does not seem to persist in the dialects for which vocabularies are at hand. Tagalog has *abohin*, gray, from *abo;* Iloco *abuen* from *abu;* Magindanao *paumbian* from *umbi*. The membership of the last in the series is perhaps open to question, but it is similar to such an undoubted member as *umbo*, ashes, in Salayer, S. Celebes (Wallace, 69). In two Philippine languages it is interesting to find the same form of the word for both the substance and the color: Bisaya *abo* (24) and Subanun[5] *gabu* (26). Strangely

[4] Brandstetter (11) says that *awu* is the Common Indonesian form.

[5] Among the Philippine languages are several which have the same word or simple variants of the same word for ashes and lime. The origin of this relation is easy to understand, since lime is produced by "burning" coral, shells, or some such material. Churchill (26) has not observed this fact, and seems to the writer to be in error in identifying Subanun *apog*, lime, verbally related to *gabu* (= *gabo*), ashes, with Samoan *punga*, Fijian *vunga*, Tonga *bunga*, etc., meaning coral.

enough, therefore, in view of the poverty of most of the Indonesian languages in color words, cognate words for gray seem to be as widely distributed and as generally used as the words representing such primary conceptions as white, red and black.[6] It seems not unlikely, however, that the color significance is secondary, and has been independently derived from the same source in many languages.

KOENING, *yellow* — The Malay word for yellow runs through many languages with only slight phonetic variation. It is fundamentally the same as the plant name *koenik*, Curcuma, the rootstock of which is prized for its intense yellow color. The writer (4) has shown *koenik* to be Common Indonesian. In the sense of yellow it is likewise very widespread, as the following list (largely from Wallace, 69) will show, but it does not seem to extend into the Philippine area, as the plant name does, on which account the color significance is looked upon as secondary: *koening* (Gajo), *hoenik* (Toba), *kuniĕng* (Minangk.), *koening* (Jav.), *kuniq*[7] (Tontemboan), *makuni* (Boeton), *koening* (Sula), *konin* and *koni* (Boeroe), *ununing*, *kunukunu* and *masikuni* (Seran), *kuni* (Teor), *kuning* (Badju). There are other series of names for yellow in Indonesia and some names that appear to be isolated. In the Philippines some of the languages have their word for yellow from *dilao*, another name for Curcuma. This fact is likewise an indication that the word for the plant in the cases of both *kunik* and *dilao* is fundamental, and the color idea derived. Otherwise we might expect the word for yellow to transgress the boundaries of distribution of the related plant name. As will be noted under Karo *gĕrsing*, there are languages in which the word for yellow is related to a totally different root idea. It must be concluded that there is no Common Indonesian word for yellow, although the *koening* series is perhaps more widely distributed than any other.

IDJO, *green* — The Malay for green is *hidjau* or *idjau* in both

[6] Brandstetter (11) says: "Der Terminus Grau ist in mehreren indonesischen Sprachen eine Ableitung vom Worte Asche oder Staub, so dass 'grau' wörtlich 'aschig' ist."

[7] According to Brandstetter (11) the identical form for Curcuma also, as is likewise the case with *hoenik* (Toba).

the Peninsular dialects and Minangkabau, but *idjo* in North Sumatra. As might be expected from the general vagueness in distinguishing green, the word is not Common Indonesian, although in the form *maitsu* or *maitso* it is found in Malagasy, the most outlying language. Strangely enough, Malagasy also has *idzin*, meaning merely dark, but, as Brandstetter shows, closely corresponding with Jav. *idjem*, green. Atjehnese has *hidjo*, Gajo *idjo*, and Jav. *idjo*, beside *idjem*. The Malay word, therefore, is clearly predominant in the western islands, but it seems to reach none of the Philippine languages. The Batak languages, with *rata* for green, use a word which is more widely spread than the Malay. A more basic meaning than green for *idjo* has not been traced.

BIROE, *blue* — Apparently *biroe* is merely a modification of the English word blue. It is very widely distributed through many languages and dialects, which might cause the derivation to be doubted. However, a word which is used to describe trade goods may become rapidly and widely adopted, especially if indigenous languages give traders no words for the idea. In the form *biru* it occurs even in Africa, and in too many Indonesian languages to quote. It is found in the Philippines as *bilu* (Moro and Subanun). In the Spanish sphere of influence the usual word for blue is likewise borrowed; for instance *gasol* (Subanun) and *asut* (Chamorro) from Spanish *azul*. Subanun, at the boundary, has both the Spanish and English, just as in certain regions where Dutch influence has always predominated *biroe* (= *biru*) is replaced by *bělau* (Dutch *blauw*).

OENGOE (ONGO), *violet, Van Dyke brown, black, gray, light blue* — This word, which has the dictionary meanings purple and dark red, illustrates the vague application of color words in actual popular usage. Its derivation is unknown, and only one cognate has been recognized in a cursory search — Buginese *kamummuq*, violet or purple. The Minangkabau word is the same as the Malay.

ITAM, *black, indigo, gray* — This is one of the most clearly attested Common Indonesian color words. Although some languages do not have it, except as a borrowed word from Malay, it is

apparently an original component of the vocabulary over the whole area, and beyond. Schmidt (59) derives it from the Mon-Khmer root meaning night, finding it in Mon *bta*, Nikobar *hatom*, *dam*, night, and Santal *gadam-gadam*, at night, and *kadam-kadam*, in the dark. If there is really any relationship here, one may suggest that Indonesian has received two series of words from Mon-Khmer sources, for Malay *kĕlam*, dark; *lĕgam*, black; *kĕdam*, leaden (of sky); *malam*, night; *silam*, nightfall; all retain the root *dam* in a modification readily explained by the *h-g-r-l-d* sequence of consonant changes, in some of the examples obscured by infixation of *ĕl*, which in one case has been followed by consonant transposition. Toba *holom*, dark, has the same root, as have Karo *kĕlĕm*, period of the waning moon, and the Philippine words for night or evening, *dom* (Sulu), *malulem* (Moro), *ngarem* (Pangasinan), *imachem*[8] (Inibaloi), *masdem* (Kankanaey), *nasdem* (Lepanto), *malem* (Ilocano), and others in which the relationship is more obscure. Formosan cognates are *odum* (Favorlang), *hom-hom* (Tsui-hwan), *madung* (Pepo Kongana, 12, 58). Strict equivalents of Malay *itam*, making up a distinct series from the *dam* derivatives, which are not too certainly related to *itam*, are Malagasy *mainty*, Nias *aito*, Toba *itom*, Jav. *item*, Makassar *etang*, Boeton *amaita*, Menado *maitung*, Sanguir *maitun*, Salibabo *maitu*, Boeroe *miti*, Amboina *mete*, Seran *mete* or *meten*, Teor *meten*, Tidong *mitam*, Tagalog *maitam*, Subanun *mitom*, Lanao *maitum* and Moro *maitem*. Here there is overwhelming evidence that *itam* is Common Indonesian. That *itam* and its cognates do not always mean black is merely an example of the indefinite application of color words in Indonesia. Warneck (70) gives the meaning of *itom* in Toba as indigo-blue. Many words for black, which do not belong to the *itam* series at all, also serve for blue, as for example, Bontok Igorot has *ingitit* for both blue and black (Clapp, 16). In Batak dialects, as this paper shows, there is constant confuson in the designation even of light blue with black.

POETIH (PUTIH) *white* — This word is Common Indonesian, but, as will appear later, is by no means the only base of words for

[8] The *ch* in Inibaloi is the *d* of Ilocano, thus *chanum*, water, = *danum; chuyao*, yellow, = *duyao; chua*, two, = *dua*. See Scheerer (57).

white, since many languages, the Batak dialects, for example, have unrelated words. The Malay form runs through Atjehnese, Sundanese, Javanese, Sulu, Magindanao and several dialects of Amboina and Seran. Gajo has the variant *poetik;* Minangkabau *putiĕh;* Dyak and a large group of Philippine languages have *puti,* which varies in Tiruray to *fute* (18). Tsui-hwan *maputhi* carries the series to Formosa (20). Eastward of Borneo are *mapute* (Buginese), *maputi* (Boeton), *moputih* (Tomore), *ompoti* and *boti* (Soela and Boeroe), *mehuti* (Goram), *maphuti* (Matabello), *muty* (dialects of Timor), *pudi* (Savu), and *mavute* (New Hebrides) (17). Westward of Sumatra are *afusih* (Nias), *fotsy* (Malagasy) and *potayak* or *patuik* (Selung of Mergui, 1). Thus far no more basic meaning for *poetih* and its cognates has been found than white, and of all the words used in connection with color it is most consistently applied. Although it is Common Indonesian, there exist other words for white, a series confluent with the word for moon, discussed under Pardembanan *lopak* and Karo *mboelan,* being not merely Indonesian but also widely distributed Melanesian and Polynesian. Other synonyms are discussed under Toba *bontar* (p. 37).

SUMMARY FOR MALAY

Malay is for the Batak, as well as for the other more local Indonesian languages, the usual source of loan words. Often one is at a loss to know whether such a word as Malay *itam,* black, when it is recorded in the Toba dictionary as *itom,* dark blue, indigo color, is an ancient possession of the language or a recent borrowing. As we have seen, the meaning given in the dictionary does not assist us to draw any conclusion, for the Malay as well as the Batak often calls indigo light black or merely black. Other words that are doubtless borrowed from the Malay are so freely used in Batak that it is hard to maintain that they do not belong to the language except by the doubtfully valid argument that they exist side by side with synonyms that are not Malay. In the foregoing pages there are observations upon all the common Malay words that are found in the following lists of Batak words.

As tested in a single district, Batoe Bara, the Malay of common

speech has been found to have eleven commonly used color words. Of these, *merah*, red, *djinggo*, light red or orange, *koening*, yellow, *idjo*, green, and *oengoe*, violet, are Indonesian words which cover all but one of the spectral colors for which we ourselves have words that are commonly used with fair precision. The only marked defect in the terminology is the lack of an indigenous word for blue, which was originally called *idjo*, the same word as for green (seldom now among intelligent Malays), or *itam*, the same word as for black. Nowadays one of the borrowed words *biroe*, from the English, or *bělaoe* from the Dutch, is used by educated Malays. The words for neutralized and deeply shaded colors are *kělaboe*, gray, literally ashy, a truly Common Indonesian conception, and *tjokělat*, brown, now forced into association with the word chocolate, introduced from English or Dutch, although the Indonesians feel in it one of their own word bases, *kolat* or *kělat*. The words *itam*, black, and *poetih*, white, are Common Indonesian. The former may be used not only for black but for very dark shades generally, and the latter for any very light tints. In this respect, however, popular Indonesian usage is the same as European. In respect to the color blue, however, Malay usage deviates from our own and may indicate a racial peculiarity of color vision: (1) A very pale blue may be called *poetih kělaboe*, grayish white; (2) any hue from spectrum blue to indigo is likely to be called *itam moeda*, pale black; and (3) indigo may be called simply *itam*. Even so, a Malay may still be convinced that there is a difference between very dark blue and black, in which case he is quite likely to prefer the word *itam* for the dark blue or indigo and to call the black *oengoe*, the proper word for violet or purple. In the sections on the Batak dialects similar facts will appear. The Malay is in advance of the Batak in having words for orange and for violet or purple, which are not yet very stable or definite in their application and are much less widely known and used than the widespread words for red, yellow and green (+ blue).

Before the European words for blue were adopted into Malay there were at least two introductions to supply the deficiency, namely, Sanskrit *nila*, indigo, and Javanese *erang* (recorded in the following Javanese vocabulary as *irang*), the latter having the

meaning dark or black and used for blue-black.[9] These words occur in the older Malay literature but have no definite meaning to the average Malay.

JAVANESE COLOR WORDS

Aside from the Malay, the only people with whom the Batak are in close contact are the Javanese, of whom many thousands are employed on the plantations of the East Coast. The following list of words covers the color vocabulary of the coolie class of immigrant Javanese. It is based on the consensus of opinion of two groups, including about ten persons.

Indian red, abang toewo
grenadine red, abang toewo
rose, abang nom
brown madder, tjokolat
cadmium orange, abang
Mars orange, abang nom, koening toewo
light chrome yellow, koening nom
yellow ocher, koening toewo
Van Dyke brown, sawoe matang, irang nom
malachite green, idjo
yellowish oil green, idjo
spectrum blue, biroe nom, bělaoe
Payne's gray, idjo toewo
indigo, irang nom
amethyst violet, biroe toewo
violet-slate, irang nom
black, irang toewo
white, poetih

Although the Javanese lower classes are more cultured than most of the Batak, their common speech is almost equally deficient in color words. Neither orange nor violet is recognized by a distinct name. Dark brown, indigo and violet-slate are all light (literally, "unripe") black. Blue is recognized under the borrowed names *biroe* (Eng.) and *bělaoe* (Dutch), but the underlying Indonesian tendency to confuse blue with green is shown by the use of *idjo toewo* (dark green) for a distinctly bluish gray (Payne's gray).

The characteristic Javanese color words, *abang*, red, and *irang*, black, do not seem to have been taken over into any Batak dialect. As far as effect on the color vocabulary is concerned the near proximity to the lowland Batak of thousands of Javanese plantation coolies seems to have been negligible.

[9] The word *erang* affords an example of the perplexities of Indonesian etymology. It coincides in form with a historically distinct but etymologically identical word *erang* which means a coal of fire, and therefore connotes redness. Nevertheless it means black or dark, and is probably cognate with Mal. *eram*, which means turning dark, as the face of one ashamed.

COLOR VOCABULARY OF THE PARDEMBANAN DIALECT OF BATAK

Seventeen persons or groups of persons, most of them living in Silo Maradja, Asahan, or just across the Soengei Silo Toewa in Tanah Djawa, Simeloengoen, provided the data for the following vocabulary:

red [10]
- na gerger, red
- gerger hoelikkoeling ni djoehoet, red of the skin of the body
- merah, red (Mal.)
- satonga merah, reddish (literally, half red) (Mal.)
- oengoe, violet (Mal.)
- merah idjo, green-red (Mal.)
- masam kolat, brown
- gorsing, yellow (Toba)
- koening, yellow (Mal.)
- haboe, ash-colored
- lassat, stained, painted
- langan, faded, bleached
- honda, streaked, mottled

rose
- na gerger, red
- satonga gerger, reddish
- merah, red (Mal.)
- merah djamboe, red of the *djamboe* fruit (Mal.)
- merah darah, blood-red (Mal.)
- idjo moeda, light green (Mal.)

grenadine red
- na gerger, red
- satonga gerger, reddish
- merah, red (Mal.)

brown madder
- masam kolat, brown
- sikolat moeda, light brown
- merah, red (Mal.)
- merah djamboe, red of the *djamboe* fruit (Mal.)
- gorsing, yellow (Toba)
- haboe, ash-colored

orange
- koening, yellow
- koening moeda, light yellow
- satonga koening, yellowish

Mars orange
- koening toewa, dark yellow
- koening haboe, ashy yellow
- satonga koening, yellowish
- koening kolat, brown-yellow
- masam kolat, brown
- na gerger, red
- merah, red (Mal.)
- satonga rata, greenish

yellow [11]
- koening, yellow
- satonga koening, yellowish
- koening na langan, faded yellow
- koening poso, young (i.e., light) yellow
- koening moeda, light yellow (Mal.)
- gorsing, yellow

Van Dyke brown
- haboe, ash-colored
- sikolat toewa, old (i.e., dark) brown
- masam kolat, brown
- koening, yellow
- satonga koening, yellowish
- merah kalaboe, ashy red (Mal.)
- satonga rata, greenish
- boenga sendoeloek, the flower color of *Melastoma polyanthum* Bl., i.e., rose-purple

[10] Lists for jasper red and Indian red are here thrown together, since these shades were too close for any one to distinguish them by name. Since the qualifications *na poso* (young, i.e., light) and *na toewa* (old, i.e., dark) were used indiscriminately they are omitted.

[11] Includes light chrome yellow and yellow ocher, which were not distinguished.

Van Dyke brown (*Continued*)
masak, cooked
na langan, faded, discolored
na lassat, stained
malachite green
rata, green
rata poso, young (i.e., light) green
idjo laoet, sea green (Mal.)
honda, streaked
yellowish oil green
rata, green
rata poso, light green
rata-rata, greenish
satonga rata, greenish
idjo moeda, light green (Mal.)
koening, yellow
satonga koening, yellowish
soekelat, brown, a variant by vowel transposition of the more usual *sikolat*
rah, the Javanese word for blood
honda, streaked
na langan, faded
na lassat, stained
blue[12]
rata, green
rata poso, light green
rata-rata, greenish
satonga rata, greenish
idjo, green (Mal.)
idjo moeda, light green (Mal.)
satonga idjo, greenish (Mal.)
biroe idjo, green-blue (Mal.)
biroe, blue (Mal.) (Only three times from twenty-five informants, each of whom was presented with blue from two to five times)
satonga birong, blackish
honda, streaked

Payne's gray
idjo, green (Mal.)
idjo moeda, light green (Mal.)
biroe, blue (Mal.)
birong, black
itam, black (Mal.)
itam haboe, ash-black
satonga itam, blackish
itam moeda, light black
honda, streaked
satonga honda, somewhat streaked
indigo
rata, green
idjo, green (Mal.)
birong, black
satonga honda, somewhat streaked
amethyst violet
biroe, blue (Mal.)
idjo, green (Mal.)
oengoe, violet (Mal.)
boenga sendoeloek, rose-purple
merah idjo, green-red (Mal.)
siang malam, night brightness
honda, streaked
langan, faded
violet-slate
satonga itam, blackish (Mal.)
idjo, green (Mal.)
itam, black (Mal.)
birong moeda, light black
biroe, blue (Mal.)
black (*lamp-black*)
na birong, black
itam, black (Mal.)
itam toewa, dark black (Mal.)
idjo, green (Mal.)
idjo omboen, cloud green (Mal.)
biroe, blue (Mal.)
white
na lopak, white
poetih, white (Mal.)

[12] Various shades from spectrum blue to Prussian blue, which were not distinguished.

RELATIONSHIP OF THE THREE CHARACTERISTIC PARDEMBANAN COLOR WORDS

GERGER, *red* — In Asahan the prevailing designation for red is *na gerger*. The root occurs in Toba proper as *gor*, and the derivative by reduplication, *gorgor*, means glowing, burning, red-hot. As a color word the modification of the vowel would indicate that it came into Asahan from the Simeloengoen country to the North, rather than with the direct migrations from Toba *via* the terraces of the Asahan River. Pardembanan words brought directly from Toba retain *o*, or change it to *a*, but not to *e* or *i*. The *u* and *o* of Toba, however, are frequently represented by *i* or *e* in Simeloengoen. A search has failed to reveal a cognate of *gerger* with the principal meaning red except Simeloengoen *magirgir*, recorded by Hagen (28). It would seem, however, that Toba *gorsing* and Karo *mĕgersing* (primary meaning, yellow) are from the same root, *gor* or *gĕr*. (See discussion under *gĕrsing*, p. 41.) It is also probable that Karo and Toba *gara*, which means red-hot or glowing, comes from the same source. Brandstetter (10) quotes a sentence from the Toba story Sangmaima in which the isolated root *gor* is used in the sense of to burn. The Karo form of the root occurs in *'nggerger*, to cook something, and *tangger*, *nangger*, to cook.

MASAM KOLAT, SI KOLAT, SOEKELAT, *brown* — The terms used for brown are superficially similar to the introduced word *tjokolat*, *tjokĕlat*, chocolate, but probably antedate the introduction of the latter. *Masam* is from the widespread base *asam*, acid. *Kolat* (Pardembanan), *klat* (Gajo), *kĕlat* (Mal. and Atjehnese), *holat* (Toba), *kale* (Minangkabau) are cognate words varying in meaning (according to the dictionaries) from "acidity of taste, taste which sets the teeth on edge" (Wilkinson, 71) to "disagreeable in taste, difficult to swallow" (Warneck, 70). In Asahan the latter meaning prevails. Certain unpalatable inedible fruits are said to be *kolat*, as is scorched or unpalatable food.[13] *Masam* alone has on the whole an agreeable connotation as signifying something sour, of which the taste, if too sharp, may be made agreeable by dilution.

[13] Karo *kĕrah* (toasted scorched) may be another cognate of *kolat*. As the Karo word lists will show, it is used with the meaning brown.

Masam kolat signifies a bad taste that cannot be made agreeable by dilution. That the word connotes general distastefulness rather than mere acidity or astringency is shown by a Gajo sentence quoted by Hazeu (31) *klat kro koepaan, meningöti anakkoe ajoe maté*, "my rice is *klat* as I remember my lately dead child." The word *masam* itself covers a wider range of sensations than simple sourness, as astringency, for example, and those which are disagreeable are a modified kind of *masam*, i.e., *masam kolat.*

Just how the extension of a taste concept to a color has taken place can only be conjectured. The writer would suggest that burned food is both brown and *kolat* in taste — hence the double meaning. *Kolat* is very frequently used with the prefix *si*, *si kolat.* The form *soekelat*, also used, the writer would derive from *sikolat* by vowel transposition and modification. *O* shifts readily to *oe* (= *u*), and *i* to *e*, these vowels being so readily interchangeable that one is sometimes at a loss to know what spelling to adopt for a word. *Soekelat* conforms closely enough to *tjokelat* (the introduced word chocolate), so that the latter would not be taken for a new, introduced word at all by a native.[14] If it were used to designate brown, as it commonly is by foreigners, it would readily be accepted with this significance. The introduction of chocolate and common use of the word has perhaps helped to extend the application of taste terminology to color.

LOPAK, NA LOPAK, *white* — The Pardembanan word for white appears at first sight to be remarkably isolated but it is probably related to the words meaning moon, white, gleaming, in many island languages. It has its only closely similar cognate in the rare Malay words *lĕpak* and *lĕpang*, the former occurring in the expression *puteh mĕlĕpak*, "extreme whiteness, such as that of cotton wool" (*Wilkinson*, 71) and the latter in the phrase *ombak boenga lĕpang*, white-capped wave, which has been explained literally as

[14] Cf. Malay *tjat* (paint), Pardembanan *sat;* Mal. *tjap* (signature), Toba *sahat;* Mal. *tjampor* (mix), Toba *sampoer;* Mal. *tjandoe* (opium), Toba *sandu;* Mal. *tjatjar* (pock), Toba *sansar;* Mal. *tjapa* (wooden dish), Toba *sapa;* Mal. *tjĕrmin* (mirror), Toba *sormin;* Koealoe dialect *tjekolat* (brown), Pardembanan *si kolat.* The form *tjekolat* almost conforms to the European word *chocolate*, but the *tje* is really an exact equivalent of the separable *si*, which is not infrequent in composition.

"wave blooming like a cucumber." The only dictionary meaning for *lĕpang* is cucumber. Since cucumber flowers are yellow and never seen in mass effect, this translation is absurd without the explanation that the flowers of the wave come to nothing, just as many (staminate) cucumber flowers produce no fruit. The explanation at best seems far-fetched. A more natural one is to view *lĕpang* as an obsolete word for white, persisting only in the phrase quoted, and exactly equivalent to Mal. *lĕpak* and Batak *lopak*.

If *lopak* has been derived by consonant transposition from *polak* or *polang* it is easy to find many clear cognates, of which Tidong (Tarakan) *pulak*, white, is the best. The latter falls into a long list of words of which the primitive form is probably *bulan*, moon, also meaning white in many languages. As a matter of fact, Churchill (26) came to the conclusion that "the primal sense is that of shining, more particularly of a white light, a sense which predominates in the Polynesian of each migration. In the Pacific at present the moon word is *masina*, a conditional of *sina* white. That *pulan* is the earlier word is exhibited by the completeness of its series out of the Malay seas through Melanesia and into Nuclear Polynesia." The reader is referred to Churchill's long list of Melanesian and Polynesian equivalents. It is necessary, however, since the general meaning of the *bulan* series of words in Indonesia is moon, to bring forward examples which mean white. The best are Karo *mboelan*, Mentawei *bulao*, Iloco *pudao* and *purao*, Bisaya *pulau*, Ibanag *furau*, Bontok *pokau*.[15] The transformation of final *n* into *k* and eventually its loss probably went by way of intermediates such as the following words for moon: *bulang* (Mal. of Trengganu), *burang* (Solor), *ulang* (Kisa). Final *ng* passes readily to *k*. Many examples might be cited, but the parallel words for yellow, *kunik* and *kuning*, in even the same dialect, may suffice as an example.

[15] Ray (49) in a discussion of the Melanesian range of twenty-one words which Brandstetter (10) certifies as Common and Original Indonesian treats the words for white, among which he identifies two clear equivalents of *putih*, namely, Opa *mavuti* and Fagani *mafui*. "All the others," he says, "seem to be formed from a word-base *pusa*, which in the Philippines is *pudao*, *pulau*, and *furau*." The writer finds himself more in accord with Churchill's identification of the Philippine words with a long list of such Micronesian and Melanesian words for moon as Chamorro *pulan*, Angadi *pura*, Lakahia *bura*, Uni *bulo*, Lobo *furan*, Mota, etc., *vula*, Maewo *wula*.

DISCRIMINATION OF COLORS BY THE PARDEMBANAN BATAK

The most notable facts about the Pardembanan discrimination of colors are:

(*a*) The free use of evasions such as *langan*, faded, *lassat*,[16] stained, and *honda*, streaked.

(*b*) The tendency to use *haboe*, ash-colored, as a vague evasion rather than as an exclusive word for gray.

(*c*) The occasional confusion of red and green, showing the existence of the most usual type of color blindness.

(*d*) The lack of any designation for orange.

(*e*) The occasional inability to distinguish Van Dyke brown from rose-purple.

(*f*) The use of exactly the same names for green and blue by all except a negligible minority.

(*g*) The failure of even a single person to give a different name to indigo and emerald green, except when indigo and often all other shades of blue were verbally confused with black.

(*h*) That gray as well as all tints and shades of blue may be called black, and black may be called green or blue, but green is seldom called black.

(*i*) That the Malay word for violet (*oengoe*) is in use, but is as likely to be applied to red or red-brown as to violet.

(*j*) That those who do not use a proper word for violet, and recognize it as a mixed color, call it green-red rather than blue-red, even if they have taken over Eng.-Mal. *biroe* for blue.

COLOR VOCABULARY OF TOBA BATAK

1. Upper Koealoe

To the south of Asahan is the sultanate of Koealoe. Here, as in Asahan, the coastal people have long been under Malay influence and have absorbed so much outside blood as to have lost their

[16] The word *latsat*, equivalent to *lassat*, which the writer feels quite certain he has interpreted correctly, is given by Skeat and Blagden (60, vol. 2, p. 540), as the word used by the Semang of Kedah for blue. It is not more likely a Malay introduction, used in a vague sense and not for a specific color? Schmidt (59, p. 82) cites Mon-Khmer words showing in this group of languages the same confusion of blue, green and black that exists in Indonesian.

Batak social organization and culture. In upper Koealoe, however, around Bandar Manis and from there inland, are many small villages and jungle groups that retain part of the old culture, keep up the old exogamous marriage groups, and speak a dialect of Toba with a large admixture of Malay words. Color words were recorded eighteen times, from as many house groups or individuals living within the boundaries of Loendoet (officially Londoet) concession, mostly at Kampong Aek Sordang and Kampong Loendoet. This district lies south of the Aek Kanopan about on a line from Bandar Poelo to Bandar Manis.

Indian red
- merah, red (Mal.)
- merah toewa, dark red (Mal.)
- satonga merah, reddish
- na rara, red
- satonga rara, reddish
- biroe, blue (Mal.)
- merah koening, yellow-red (Mal.)
- na koening, yellow
- masam kolat, brown
- satonga itam, blackish
- si lapoeh, moldy

rose
- merah, red (Mal.)
- merah moeda, light red (Mal.)
- na rara, red
- satonga rara, reddish
- koening, yellow
- satonga koening, yellowish (Mal.)

vermilion
- merah, red (Mal.)
- na rara, red
- merah moeda, light red (Mal.)
- merah poetih, white-red (Mal.)
- merah saparo, half red (Jav.)
- koening, yellow

brown madder
- satonga merah, reddish (Mal.)
- merah toewa, dark red (Mal.)
- na rara, red
- tjekolat boenga djamboe, crimson-brown (Mal.)
- masam kolat, brown
- masak, cooked (Mal.)
- satonga koening, yellowish (Mal.)
- koening toewa, dark yellow (Mal.)
- hoelaboe, ash-colored
- na lapoek, moldy
- satonga bottar, whitish
- satonga poetih, whitish (Mal.)
- holom (= holoem), dark

orange
- koening, yellow
- koening moeda, light yellow
- na rara, red
- merah koening, yellow-red (Mal.)
- satonga merah, reddish (Mal.)
- merah moeda, light red (Mal.)

burnt Sienna
- satonga koening, yellowish
- koening toewa, dark yellow
- koening, yellow
- koening na merah, red-yellow
- na rara, red
- merah, red (Mal.)
- merah toewa, dark red (Mal.)
- satonga merah, reddish (Mal.)
- merah moeda, light red (Mal.)
- merah saparo, half red (Jav.)

yellow
- na koening, yellow
- merah hoenik, yellow-red
- na rara, red
- satonga merah, reddish

Van Dyke brown
- masam kolat, brown
- tjekolat, chocolate (Mal.)
- merah kĕlat, brown-red (Mal.)
- kolat masak, cooked-brown
- masam kolat itam, black-brown

Van Dyke brown (Continued)
satonga merah, reddish (Mal.)
merah itam, black-red (Mal.)
na rara, red
na gerger, red
satonga idjo, greenish (Mal.)
idjo, green (Mal.)
biroe, blue (Mal.)
satonga bottar, whitish
malachite green
na ratarata, greenish
idjo, green (Mal.)
na rata, green
idjo moeda, light green (Mal.)
idjo kolat, brown-green (Mal.)
na biroe, blue (Mal.)
yellowish oil green
na ratarata, greenish
idjo, green (Mal.)
satonga idjo, greenish (Mal.)
rata koening, yellow-green
na rata, green
satonga ratarata, somewhat greenish
itam koening, yellow-black
djingga, orange (Mal.)
satonga masak, half-cooked
kolat, brown
langan-langan, as if faded, discolored
satonga merah, reddish (Mal.)
spectrum blue
idjo, green (Mal.)
satonga idjo, greenish (Mal.)
idjo moeda, light green (Mal.)
na rata, green
na ratarata, greenish
biroe, blue
masam kolat, brown
na birong, black
satonga itam, blackish
Payne's gray
satonga itam, blackish (Mal.)
na birong, black
itam, black (Mal.)
idjo, green (Mal.)
satonga idjo, greenish (Mal.)
na biroe, blue (Mal.)
indigo
na idjo, green (Mal.)
idjo itam, black-green (Mal.)
itam, black (Mal.)
na birong, black
satonga itam, blackish (Mal.)
itam poetih, white-black (Mal.)
masam kolat, brown
oengoe, violet (Mal.)
violet
na idjo, green (Mal.)
idjo itam, black-green (Mal.)
idjo kolat, brown-green (Mal.)
satonga idjo, greenish (Mal.)
biroe, blue (Mal.)
merah djamboe, crimson (Mal.)
satonga merah, reddish (Mal.)
na koening, yellow
masam kolat, brown
na kolat, brown
satonga itam, blackish (Mal.)
na holoem, dark
black
na birong, black
satonga itam, blackish (Mal.)
itam poetih, white-black (Mal.)
itam toewa, dark black (Mal.)
satonga idjo, greenish (Mal.)
biroe, blue (Mal.)
white
na bottar, white
na poetih, white (Mal.)

Only two informants gave other than the expected names for black. In both of these cases the paint was thinly applied and appeared grayish. It was then called green or bluish. The informant who called it green seemed quite unable to distinguish it from either spectrum blue or malachite green, which looked the

same to him. He applied the designation *satonga merah*, reddish, to brown madder, Van Dyke brown, orange, yellow, olive-green, violet.

2. Habinsaran

In the mountainous country between Toba proper on the west and Asahan and Koealoe on the east the language spoken is practically pure Toba. There were enough differences in color nomenclature, however, so that it did not seem best to throw the data in with those for Toba proper. The differences were not so much in the prevailing color words as in the less frequent words and expressions. The influence of missionary schooling in Toba showed in the adoption there of the Dutch word for blue. The Habinsaran tests showed much less missionary and more Malay contact. Ten records were made in Habinsaran, mostly representing group rather than individual opinions, but, as always, a single spokesman gave the final answer to each question, the rest acquiescing.

Indian red
- na merah, red (Mal.)
- na rara, red
- na bara, red
- na gerger, red

vermilion
- na rara, red
- na merah, red (Mal.)
- na koening, yellow

crimson
- na merah, red (Mal.)
- na rara, red
- na djelak, bright and clear (= Mal. djelah)

brown madder
- na rara, red
- na merah, red (Mal.)
- satonga gerger, reddish
- koening, yellow
- na hinoenik, yellowish

chrome yellow
- na koening, yellow
- na hoening, yellow
- na hoenik, yellow
- na hinoenihan, yellowish

yellow ocher
- na koening, yellow
- na hoenik, yellow
- hoenik merah, red-yellow
- ñá ratarata, greenish

Van Dyke brown
- na koening, yellow
- na hinoenik, yellowish
- na rara, red
- na merah, red (Mal.)
- na gerger, red
- satonga gerger, reddish
- nedjo (= na idjo), green

orange
- na koening, yellow
- na hoenik, yellow
- na nihoenihan,[17] yellowish

burnt Sienna
- na koening, yellow
- na hoening, yellow
- na hinoenik, yellowish
- na rara, red

malachite green
- na idjo (= nedjo), green (Mal.)
- na rata, green

[17] By consonant transposition from hinoenihan, but an approved word.

malachite green (Continued)
na ratarata, greenish
na birong, black
bělaoe, blue (Dutch)
yellowish oil green
na ratarata, greenish
na rata, green
na idjo, green (Mal.)
na koening, yellow
na hoenik, yellow
spectrum blue
na birong, black
satonga na birong, blackish
na idjo, green
biroe, blue (Mal.-Eng., 1 reply)
na gerger, red
Payne's gray
na birong, black
na idjo, green (Mal.)
birong na bottar, white-black
itam, black (Mal.)
na gerger, red
indigo
na birong, black
na itam, black (Mal.)
satonga na birong, blackish
bělaoe, blue (Dutch, 1 reply)
violet
na idjo, green
na gerger, red
na merah, red (Mal.)
na boengaboenga, flower-color
biroe manis, pale (literally, sweet) blue
violet-slate (named only twice)
na birong, black
black (lamp-black)
na birong, black
na itam, black (Mal.)
na idjo, green (Mal.)
white
na bottar, white
na poetih, white (Mal.)

3. Toba proper

In the densely populated region about the south end of Toba Lake, Toba proper, twenty individuals or groups identified the color samples, as follows:

Indian red
na rara, red
na bara na matoewa, dark red
na rara holoem, dark red
na garagara toewa, dark reddish
moedar, blood (red)
djelak, bright, clear (applied only to red)
merah, red (Mal.)
na rara na gorsing, yellow-red
na hoenik, yellow
na latsat, stained, dyed
vermilion
na rara, red
merah, red (Mal.)
na djelak, bright, clear
rose
na rara, red
na merah, red (Mal.)
na djelak, bright, clear
moedar, blood, red
koening, yellow
na hain, like cloth
brown madder
na rara toewa, dark red
na rara, red
na bara, red
alang na rara, not quite red
na gerger, red
na merah, red (Mal.)
na gorsing, yellow
alang na gorsing, not quite yellow
na idjo, green (Mal.)
taritam, somewhat black
na latsat, stained, painted
chrome yellow
na hoenik, yellow
na koening, yellow

chrome yellow (Continued)
na hoenik si toetoe, genuine yellow
lappiang, ginger color
na ratarata, greenish
yellow ocher
na hoenik, yellow
na hoenihoenihan, yellowish
na koening, yellow
na bara, red
na rara, red
na langan, faded
Van Dyke brown
na gorsing, yellow
na toewa, old, (i.e., dark)
na hoenik, yellow
na koening, yellow
hoelikkoeling, skin color
tjokolat, brown (Mal.)
na rara, red
na rara tano, earth red
na rara matoewa, dark red
na bara na matoewa, dark red
na latsat na rara, red stained
orange
na hoenik, yellow
koening, yellow
na hoenik toewa, dark yellow
na hoenik si toetoe, genuine yellow
alang na hoenik, not quite yellow
na rara koening, yellow-red
na rara, red
na gara, red
merah, red (Mal.)
burnt Sienna The simple word for green was the most frequent designation, but various ways of expressing yellow or red predominated if grouped although each name was used by only one or two informants. The words for yellow and red are therefore placed first in the following list.
na hoenik, yellow
koening, yellow
alang na hoenik, not quite yellow
na hoenik na matoewa, dark yellow
na hoenik na gorsing, yellow
na gorsing, yellow
na rara hoenik, yellow-red
na rara na gorsing, yellow-red
na rara, red
na bara, red
na marmoedar, blood-stained
merah, red (Mal.)
na idjo, green (Mal.)
panoebaran, a false color or changeling
malachite green
na rata, green
na rata si toetoe, true green
na ratarata, greenish
alang na rata, not quite green
na idjo, green (Mal.)
na bělaoe, blue (Dutch)
na birong, black
itam, black (Mal.)
yellowish oil green
na koening, yellow
na hoenik, yellow
na gorsing, yellow
na rata, green
na rata holoem, dark green
na ratarata, greenish
na idjo, green (Mal.)
pege, ginger color
na birong, black
spectrum blue
na bělaoe, blue (Dutch)
na rata, green
na rata holoem, dark green
alang na rata, not quite green
idjo, green (Mal.)
oemboen (= omboen), cloud color
oppoen (= omboen), cloud color
na birong, black
itam, black (Mal.)
Payne's gray
na birong, black
na birong na matoewa, dark black
alang na birong, not quite black
itam, black (Mal.)
na rata holoem, dark green
na idjo, green (Mal.)
alang na rata, not quite green
na holoem, dark

indigo
na birong, black
na birong si toetoe, true black
na birong holoem, dark black
satengah birong, blackish
itam, black (Mal.)
agong, charcoal (i.e., black)
idjo, green (Mal.)
na ratarata, greenish
na ratarata na birong, black-greenish
bělaoe, blue (Dutch)
bělaoe na birong, black-blue
loemloem, dark [18]
violet
alang na rata, not quite green
na rata na poso, light green
na ratarata, greenish
idjo, green (Mal.)
na gerger, red
na rara birong, black-red
merah, red (Mal.)
na birong, black
itam, black (Mal.)
na gorsing, yellow
satengah bělaoe, bluish (Mal.-Dutch)
na langan, faded
violet-slate
na birong, black
satengah birong, blackish
itam, black (Mal.)
na holoem, dark
black (lamp-black)
na birong, black
na birong na matoewa, dark black
na birong tano, earth-black
na birong holoem, dark black
na birok si toetoe, true black
itam, black (Mal.)
na holoem, dark
agong, charcoal (i.e., black)
white
na bontar, white
na bottar, white
poetih, white (Mal.)

RELATIONSHIPS OF THE CHARACTERISTIC TOBA COLOR WORDS

RARA, GARA, BARA, *red* — In the Batak dialects these three words are commonly used for red. The first form is most general in Toba, but the other two are used interchangeably with it. The second form prevails in Dairi (65) and (as *mĕgara*) in Karo. The third, according to Van der Tuuk (65), prevails in Mandailing, but a manuscript vocabulary of the very closely related Angkola dialect in the writer's possession gives *rara*. It is possible to view *gara* as a phonetic modification of *rara*, but in Angkola *gara* is flame, blaze, suggesting as a more plausible derivation *gar* (= *gor*, = *ger*), glowing, burning, + *ra*, red.. (See discussion of *gerger*, p. 19, and *gorsing*, p. 41.) The third form, *bara*, cannot be viewed, even in Toba, where it is used interchangeably with *rara*, as a phonetic modification of the latter. It is a very ancient compound which

[18] The word *loemloem* does not appear in any vocabulary or text as far as the writer has noted, but is interpreted as a reduplication of the same root *loem* which occurs in Toba *holoem* (= *holom*), dark, and in many words of the same or similar significance in related languages. The list is given in the discussion of Mal. *itam*, p. 12.

runs through many languages in the sense of a live coal, firebrand, or with some very similar meaning. Kern (37) lists Mal. *bara*, Old Jav. *wa*, Mongondou, Tagalog, Bisaya, Ibanag *baga*, Tombulu *waha*, and Jav. *wawa*. Mentawei (44) has exactly the same word, *bå*, for glowing coals and red. Dyak (Olo Ngadjoe) *bahe*, Tontemboan *va'a*, Dairi (65) *ombara*, Moro (35) *waga* are additional cognates. In all of these bisyllabic words (Dempwolff, 22, derives Old Jav. *wa* and Mentawei *bå* from bisyllabic forms by the suppression of the "inlaut" *r*) the final syllable is *ra* or a modification of it. Neither Kern nor Dempwolff suggests that this *ra* is identical with the *ra* of the similar words for red, *rara* and *gara*, but that it must be is indicated by the connotation of redness, heat, or sun in a long list of words contaning *ra* or its phonetic equivalent. If we consider only words not cited in other connections there are Maori *kura*, red, *mapura*, fire, *miramira*, glowing red, Samoan *mafulu*, glowing, Fijian *ula kula*, *kura*, Gilbert Is. *ura*, red, Tagalog *pola*,[19] Bisaya, Iloco, Bikol *pula*, *mapula*, Ibanag *fula*, Subanun *pulo*, Moro *miriga*, Mongondou *mopura*, Ponosaka *puha*, red. Many more might easily be found. The *r*, *l*, *g* and *h* of the final syllable represent easy and frequent mutations of an original *r* or *d*. (Some of these examples are discussed by Kern, 37, and Dempwolff, 21.) The evidence seems overwhelming that *ra* is a frequent syllable in bisyllabic word bases meaning red. This *ra* is the same syllable that occurs in the reduplicated *rara* of Batak, in this group of dialects meaning red, and also in the word for blood in a great many languages.

Kern considered the words for blood as descendants of a very ancient reduplication of a syllable *dah* or *deh*, of which *ra* is a variant. Ray (49) has recently drawn up a table of those words which appear to have the most extended distribution in both Indonesia and Melanesia. It includes among others the following words for blood which he views as etymological equivalents:

[19] The Tagalog cognate *pola* is interesting because it has become an abstract word for color. There are few Indonesian languages that have a word that really means color. Malay has *warna*, from the Sanskrit, and other languages (e.g., Batak) use *rupa*, also Sanskrit, with the broader meaning "appearance." *Rupa* applies to form and texture as well as to color.

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Tagalog *dugo*,[20] Bugis *dara*, Olo Ngadjoe *daha*, Old Jav. *rah*, Nias *do*, Malagasy *ra*, Bima *raa*, Raluana (New Britain) *gap*, Uruava (N. Solomon Is.) *revai*, Fiji *dra*, Mota (Banks Is.) *nara*, Pangkumu (N. New Hebrides) *re*, Nguna (C. New Hebrides) *da*, Eromanga (S. New Hebrides) *de*, Iai (Loyalty Is.) *dra*. To this list may be added almost all the words for blood in Indonesian languages, e.g., Malay and Minangkabau *darah*, Gajo *rajoh*, Malagasy *dra* and *ra* (17), Nias *do*,[21] Selung *dallak*, Chamorro *haga*, Ibanag *daga*, Inibaloi *chala*, Subanun *dogo*, Pampanga *daya*, Tombulu *raha*, Saleijer *rara*, Tonsea and Tonsawang *daha*, Amboina *lala*, Menado *daha*, Bolang-hitam (N. Celebes) *dugu*, Sangir, Sian *daha*, Sula *poha*, Buru *lala*, *raha*, Saparua *lalah*, Seran *lalah*, *lala*, *laia*, *lawa*, Matabello and Teor *larah*, Badjoe *lahah*, Sumba *rae*, Letti and Kisar *rare*, Dawalôr *rayo-l*, Aru *raya*. All forms, if correctly placed in this series, may be taken as reduplications of a root *ra*, of which a still more ancient form, according to Kern (37), seems to have existed in the basic language stocks in such variations as *ḍah* and *ḍĕh*. By reduplication and by transformation of *d*, *r* and ', he supposed the bisyllabic forms to have arisen. As to such monosyllabic forms as Malagasy *ra*, Fiji *dra*, Alor *ra*, Timor *nah*, Rotti *dak*, Sawu *ra*, with which Tontemboan *ĕnda* may be placed, it is not clear whether they represent the unreduplicated root or contractions of a reduplicated form, in which case they would be comparable to Old Jav. *rah* (from *ra'ah*) and Nias *do*. The Kei *lar* is from bisyllabic *larĕh* or *larah*, and Moa *ra* is similarly explained, but there is a residue of words that have not yet been explained except as originally monosyllabic, such as Fijian *dra*,

[20] In Tagalog the most exact equivalent is not *dugo* but *daga*, blood relative (Dempwolff, 22) — an example of the retention of the primitive form of a word in a restricted sense side by side with a modified form expressing the original concept. Dempwolff, as a matter of fact, derives Bisaya *dugo* (certainly the same as Tagalog *dugo*) from putative original Austronesian *djuruh*, sap, rather than from *darah*, which he accepts as the original Austronesian for blood. That he may not be correct in this case is shown by the existence in Bisayan of *duga* (55), sap, cognate with his *djuruh*, side by side with *dugo*, the equivalent of *darah*. (For the sake of intelligibility, the writer has taken the liberty here and elsewhere to quote Dempwolff in the usual spelling of the sources, rather than in the phonetic transcription used by him.)

[21] From *dara* by dropping out of *–r–*, parallel to *bo*, live coal, from *bara*.

which, reduplicated, has given *dradra*, and Marindinese (40) *do*, meaning red as well as blood. Kern does not compare such words for red as Fijian *kula-kula*, Samoan *ula*, with the words for blood. Neither does he suggest any relationship between Batak *rara*, red, and the Batak words for blood, which are *daro* (Simeloengoen, Toba), *dareh* (Karo) and *moedar* (Angkola, Toba, Pardembanan). He does, however, suggest a comparison of Batak *rara* with Fijian *rara*, warm season, *in damu i rara*, "a drought when nothing is green," *rara*, to warm oneself at the fire, *i rara*, place or means of warming oneself, *rara-botabota*, red, especially the redness of ripeness or overripeness. He compares the latter with a derivative of Batak *rara*, namely, *si rara-on*, the redness of the rice field at harvest time. If the latter suggestion is to be taken seriously there must be many cognates of Fijian *rara* in the region between Sumatra and Fiji. These would seem to be represented by a long series of words connoting dryness, ranging from Fiji to the Philippines and Java, and including the following correlated with one another by Kern (37) himself, but not related by him to Fijian and Batak *rara:* Fijian *mada*, dry, Ibanag *maga*, *mamaga*, Tagalog *mala*, *mamala*, Seran *mamala*, Sangir *mamara*, Makassar and Bugi *mara*, dry, Tombulu *pĕra*, dry, *mĕra*, to dry, Jav. *pĕra*, dry. To this list may be added Malay *merang*, the general condition or color of the ripe rice plant, and probably also the commonest Malay word for red, *merah*. If *para* has the fundamental significance dry, the meaning of the name of the hanging structure (*parapara*) over the Batak fireplace, where all sorts of things are placed to keep them from molding or to dry them, becomes obvious. It is the drying place. In the same category fall the words which Schmidt (59) cited to establish a connection of the root word *ra* and its compounds in the Pacific with the Mon-Khmer languages, namely: Aru, Alor *lara*, Moa, Letti *lere*, Kei *ler*, Buru, Sula *lea*, M. Seran *lea-na*, Rotti *ledo*, Sawu *lodo*, sun, heat, Mota *rara*, Motu *rarara*, to dry by fire, Polynesian *ra*, *la*, sun, heat, Hawaiian *ra* and Tahiti *rara*, to dry by the fire, Tonga *laalaa*, dry, Bahnar *dra*, to dry by heat or in the sun, Stieng *ram*, warm, hot, Santal *gorom*, hot, Mon *gra'*, overripe, Khasi *srah*, pale red, yellow-brown.

The writer believes that the words for red have the most

ancient lineage of any Indonesian color words and probably were taken in the first place from the word for sun. The latter would naturally give rise to the words for dry, and also to a color word, indicating red, orange, yellow, brown generally, because it is during the dry sunny season that ripening of the crops and drying of other vegetation takes place and also because of the sky colors at sunset and the color of the sun itself when rising and setting. The sun would be associated with redness, and the root for red appears to have been the same as or a modification of the root for sun. The *darah* series of names for blood and the *bara* series of names for coals of fire would arise as derivatives of the word for red or the latter directly from the root *ra*, sun or heat. Thus in the languages of the Pacific many of the words for redness, dryness, sun and blood appear to have the same origin. The etymological lines of descent may often be made out through application of phonetic laws, where such have been established, but with the great number of migrations that have brought modifications of the same basic roots to the island world, each to start there its own train of modifications, to form its own derivatives, to be borrowed back and forth, and to cause the modification of other words or be modified itself when in form it suggested too closely or was identical with some other word of different meaning, it is quite out of the question to trace every word for red with certainty, or to be even reasonably sure which words for red are the most ancient and which are secondary or tertiary. Some have come from a word for blood, but the word for blood itself came from a word for red. Some are directly from the word for sun, and some from the appearance of crops or vegetation after being ripened or dried by the sun, and some from a word for live coals which itself had its origin from the word for sun, since coals suggested the sun in color, heat, and drying power.

DJELAK, *bright red* — As a color word, *djelak*, of which the meaning seems to be bright, clear, pure, was applied in Toba only to the brighter tints of red. The same word occurs in Malay as *djelah* and is used in somewhat the same way. (Badings, 3, gives Mal. *djelah* as clear, pure, high, as applied to color, specifically to red.)

RATA, *green* — The word for green is a distinctly interesting

one. With the same meaning it is found in all the dialects of Toba, and Karo has *měratah*. In both Toba proper and Pardembanan, however, it also means flat (of leaves not crinkled by wilting). Fresh meat is also *rata*. As a color word it is inclusive indeed, since the blue sky is *rata*. In related languages cognate forms are widespread, but generally mean only flat, fresh, or the like. Gajo and Malay have *rata*, Minangkabau *rato*. Skipping over the intervening islands to the Philippines, Bontok *chata*[22] means plain. At the other geographic extreme, Malagasy has *ratana* for plain. In Malay two words related to *rata* are *datar* and *natar*, flat or smooth, which also have their cognates in other languages. In Borneo the Bolongan dialect of Tidong has *rata*, whereas the other dialect, Tarakon, has *datal*, cognate with Mal. *datar*. Moro has *datar* and *pantar;* Pangasinan *mapatad*. Tagalog *latag* means spread out or extended. These obviously equivalent words cover the linguistic area so well that *rata* may be considered Common and Original Indonesian in the sense of fresh, flat, etc. Although the use of *rata* to designate color is apparently secondary and local, there is a Philippine parallel to Batak usage in Inibaloi *ma-ata*, which, according to Scheerer (57) is used for "light, fresh green of grass or leaves . . . but this word covers really only the meaning of 'vivid'." Both the Batak dialects and Inibaloi are among the languages that lack the General Indonesian word *idjo* for green, and are alike in the general confusion of black with blue or of green with blue.

BIRONG, *black* — The Common Indonesian word for black is *itam*, as noted already. *Birong* is interpreted by the writer as belonging to a widely diffused word series which originally referred, perhaps, to black, dark red, or to dark colors generally, being related to the Common Indonesian word for charcoal. The words of this series which denote color, however, are much less widely spread than those with the primary meaning charcoal, and seem

[22] That this identification is justified may be shown by citing from Jenks's vocabulary (32) a number of cases where *d* of the Indonesian *r–l–d* series is represented in Bontok by *ch:* Bont. *ochan*, rain, Inibaloi *uran*, Mal. *oedjan*, Toba *oedan;* Bont. *chěnum*, water, Iloco *danum*, Moro *lanao*, Mal. *danao;* Bont. *chala*, blood, Mal. *darah;* Bont. *chuwa*, two, Mal. *doewa;* Bont. *chila*, tongue, Toba *dila;* Bont. *chalan*, road, Mal. *djalan*, Toba *dalan*.

to have arisen by a variety of processes — by change of meaning with no change of form, by composition with formatives and by vowel transposition either in the original word or in derivatives beginning with a formative of which the consonant is *b* or *w*.

Areng, charcoal, preserved in Javanese, is supposed to be the original word base, or very near it. By vowel transposition it became *erang*, with a new meaning. *Areng*, by composition with the formative *bu* (or *bĕ*), may be supposed to have given such forms as Sasak *bireng*, Bandjar *wirang*, Dayak *buring*, Dairi *ombereng*, Karo *biring*, and Toba *birong*. In Toba *o* generally represents a primitive *ĕ*, which generally survives in the Karo word as *ĕ*. In the present case the Karo word is *biring*. There are, however, plenty of other words in Toba that have *o* as the equivalent of Karo *i* or Malay *a*. Among them are: K. *hoedin*, cooking pot, T. *hodon:* K. *itik*, a small fish, T. *itok;* K. *oewis*, cloth, T. *oelos*, Mal. *ulas;* K. *rapit*, fastened together, T. *rapot*, Mal. *rapat*.

Without pursuing further the argument that Toba *birong* is related to Jav. *erang*, we may consider some of the other cognate words. Gajo and Atjehnese *biring* is yellowish red or brownish yellow — the color of the most prized fighting cocks. Malay, a language made up of many Indonesian contributions, seems to have several forms of the word, namely, *biring*, with the same meaning as above and perhaps borrowed from Atjeh; *beram*, a dark color, dark red; *erang*, black, dark red, dark blue; *merang*, red, the color of the ripe rice. *Erang* is the same as the Javanese, and, in the sense of a very dark color, probably borrowed. Kern (37) cites various etymological equivalents with the derived meaning ashamed (dark with shame). They are Old Jav. *irang*, *erang*, *merang;* Jav. *wirang*, *mirang;* Soendanese *era;* Tombulu *mairang*.[23] Javanese *merang* is also the color of the rice field at harvest time, and therefrom the name of the ripe rice plant itself.

Javanese *erang*, red, may be derived from *areng*, charcoal, by metathesis, a phenomenon very common today in the Indonesian

[23] Kern also includes Toba *ira*, probably correctly, but the word has so far lost the original meaning that the identification seems doubtful. *Ira* means to follow with the eyes, furtively, as a thief might who wished to steal something; to be ill at ease.

languages which seems to have been a primitive mode of forming derivatives. Examples of both vowel and consonant transposition are abundant.[24] Any visitor among a Malayan people soon learns how fond they are of playing with the vowels of their bisyllabic words. The names of spirits, especially in the invocations, are expanded into long formulae by regular vowel metatheses and mutations. If there were a spirit named charcoal, for example, he might be most respectfully and potently addressed as *Siareng-irong-urang-oring-erang*, or something of the sort. Throughout a whole district a common word may, for various reasons, become prohibited (*pantang*, as the Batak say) and must then be replaced by a substitute, which may be formed by metathesis. In the writer's opinion a clear case could be made for metathesis as a frequent method of word formation where a relation of two concepts is to be suggested by similarity of sound. Hence, *areng*, black coal, *erang*, hot coal, or *areng*, charcoal, *erang*, the color of charcoal, black or dark, or red. Which came first would be difficult to say. The writer does not wish to appear to derive too much of a language from half a dozen roots, or he might argue that *erang* was first, and was related to the root *ra*, red. It is at least as likely as that *areng* was first. Some of the derivatives of *erang* already cited connote a change of color, namely, the words for darkening with shame, cited where the idea of a color change might be related to the color change of charcoal from red to black, or *merang* as the color of a ripening crop, where a change is suggested. Some of the words for red, derived from *erang* and *ra*, may have been assimilated to words derived from the root *dam*, *gam*, etc., meaning dark, as suggested in the note on Malay *merah* (p. 8).

The series of words for charcoal, which Kern (37) has traced all the way to Polynesia, provides a number of variations that are parallel to the more greatly deviating members of the *erang* (red) series, and justify the inclusion of such forms as Toba *birong* and

[24] A probable example of consonant metathesis which occurs in the color vocabulary is Mal. *lĕgam*, black; Karo *lĕgam*, completely extinguished (of coals); Karo *gĕlam*, brown or reddish brown layer which adheres to coconut flesh removed from shell, the outer coat of dark-colored rice; Mal. *kĕlam*, dark. In this example *gam* is a form of the primitive root for dark. It becomes *gĕlam* by infixation of the formative *ĕl*, and *lĕgam* by metathesis.

Karo *biring* as cognates of *erang*. The charcoal series, according to Kern, includes Mal. *arang*, Jav. *areng*, Toba *agong*, Malagasy *arina*, Boegi *using*, Ponosakan *buing*, Bentenan *woheng*. Tondano, Tonsea and Tombulu *wuring*,[25] Dayak *buring*, Ibanag and "Formosan" *uging*, Bisaya, Tagalog and Pampanga *uling*. Additions to Kern's list are Karo *ageng*, Gajo *börö*, Bontok *kalang*, Inibaloi *uling*, Lanao Moro *oring*, Iloco *uging*.

The list shows that Dyak *buring*, which has been cited as a word for black, parallel in origin to Toba *birong*, is by no means isolated except in meaning. The similar words of related languages mean charcoal instead of black. Several words in languages spread over a large area begin either with *b* or *w*, and show that there was some regular formative by which they were produced. Brandstetter (10) refers briefly in one of his essays to a rare formative element *bu*, which may explain the words with which we are concerned. He states that it serves to make word bases out of roots, and gives two instances of its occurrence.

To summarize briefly, there is a Common Indonesian word for charcoal, probably *areng* in its primitive form, from which has been derived a somewhat less widely diffused series of words meaning black, red, glowing, changing color, ashamed. The derivation of words for black and red from the same source is explained by the fact that charcoal is either black, if cold, or red, if glowing. A language in which there is a connection between the words for charcoal and glowing is Bontok, in which *kalang* is charcoal and *langlang*, a reduplicated form, means glowing. A verbal form, *malanglangan*, means casting a glow upon. It would be only a step to the development of a strict color word (for red) at a new center, just as the writer has assumed that *areng*, charcoal, developed in the southern Indonesian region into words for both black and red, and as *gerger*, glowing, has lost its primary significance in Pardembanan and has acquired the meaning red.

[25] A number of languages have two forms of the same word, one anciently their own, which has undergone the phonetic modifications proper to the tongue, and one unmodified, probably a much more recent introduction. Thus Tombulu, Tontemboan, Tonsea, and Tondano have exactly the Javanese *areng*, with the meaning soot.

AGONG, *black* — This word, which occurs in the Toba lists, is exactly the same as the Toba word for charcoal. Linguistic history seems merely to be repeating itself, and the modern representative of the same old word *areng* which has already contributed *birong* to the vocabulary has again, perhaps on account of the use of *birong* for a whole series of colors which are now beginning to be distinguished, entered into the language as a color word.

BONTAR, BOTTAR, *white* — Schmidt (59) relates Mal., Sundanese, Jav. *katara*, Kawi *tara*, Malagasy *tumartara* (from *tartara* by infixation of *um*), transparent, plain, to Santal *tartaria*, pure, clear, and Bahnar *tar*, luminous white. To this group would seem to belong Toba *bontar*, *bottar*, white, and Karo *běntar*, white. Other exact cognates have not been encountered and no more primitive meaning than white or transparent can be suggested. The word *bontar* is used euphemistically in the language of invocations, etc., in place of blood.

GENERAL REMARKS ON TOBA

A glance through the several localized lists of color words in the Toba language shows relatively little difference in usage, either as to words or their application, in the several localities represented. It becomes obvious that the Pardembanan dialect spoken in Asahan is distinguishable chiefly because of the adoption of words derived from the Simeloengoen region to the north.

In the Koealoe vocabulary the following peculiarities and tendencies may be noted:

(1) The use of the peculiar evasion "moldy" (*si lapoeh*, *na lapoek*) for dull colors, and also of *holom*, dark, as a vague color designation.

(2) A word for orange, the introduced *djingga* (Mal.), is rare and so little understood that it is applied to a yellowish green.

(3) Blue, as usual, is generally confused with green, or, if not with green, with black.

(4) Indigo and violet are frequently matched with dark brown, the same names being used.

Noteworthy points in the Habinsaran list are:

(1) That malachite green is sometimes called *birong* (black)

and vice versa. Although the names of blue and green are generally confused, and blue and black nearly as commonly, green is seldom called black by the Batak.

(2) That blue is more often confused with black than with green in this district. It seemed almost as if blue to the natives appeared neutral, as though its various shades and tints could be made by dilution of black. If this is the truth, it would explain why blues might be seen as green if there were a green component at all, since blue would not register. Furthermore it would explain why violet and red were confused, the blue component of the violet perhaps not registering, as some of the natives see it.

All the Toba lists show general confusion of blue with green, and also of blue with black. (The latter is especially true of indigo and black.) A Toba school teacher from a mission school attempted to explain to the writer that the Toba language had no word for blue because there was nothing of that color in the country before the Dutch came. I asked him if the sky, and Toba Lake, and their own indigo dye had changed their color since the Dutch came. He was considerably embarrassed, and the villagers, who he had just said were stupid because they did not use the word *bělaoe*, were greatly delighted.

The uncommon use, not only in Koealoe and Habinsaran, but even in Toba proper, of *gorsing*, yellow, was especially interesting in view of the fact that it is the only word for yellow given in Stap's vocabulary (61). *Hoenik* was much more general, and was consistently applied to yellow or orange, whereas *gorsing* was not applied to yellow ocher or to chrome yellow at all and only occasionally to such diverse colors as brown madder, Van Dyke brown, burnt Sienna, yellowish oil green, and violet. In view of the origin which has been adduced for the Karo cognate *měgěrsing* (see p. 41) it seems obvious that the word is a borrowed one in Toba, where it is used very vaguely, and not at all for yellow and flame red, to which it might reasonably be applied. In general, color words out of their proper range seem often to have been adopted with changed meanings.

Characteristic of Toba is the variety of words for red, of which *rara*, *bara*, *gara*, *merah* and *djelak* are all commonly used; but

gerger (a stray from Simeloengoen) infrequently and generally incorrectly.

On the whole, Toba color nomenclature is inferior to Malay, because of the lack of words for orange and violet. There is little evidence of a tendency in Toba proper to adopt or develop a specific word for brown, such as *tjokolat*. It is only rarely in Toba, as in Pardembanan, that a comparison with the color of the skin is used to express the concept brown. Such a comparison would seem to be a most natural one, but it has never given a color word of more than local or rare use.

COLOR VOCABULARY OF KARO BATAK

Thirteen color tests were made on the Karo plateau, mostly in the vicinity of Bĕrastagi. The more important colors were included more than once in each test, on different sheets, and the first sheet filled out was removed from sight before the second was shown. Although Karo is, in respect to the number of words in common, closer to Malay than are the other Batak dialects, the speakers are astonishingly conservative about adopting Malay words, as will be seen from the following lists. Moreover, they have not been greatly influenced by European conceptions of color, as is shown by their persistence in calling pure greens and blues by the same name.

Indian red
- mĕgara, red
- mĕgara mĕtoewa, dark (i.e., old) red
- mĕgara ngoeda, light (i.e., young) red
- mĕgambĕr, color of gambir dye
- mĕtempara, sooty, smoky
- mĕkĕlaboe, ash color

rose
- mĕgara ngoeda, light red
- mĕgara, red
- mĕgaragara, reddish

brown madder
- mĕgara mĕtoewa, dark red
- mĕgara, red
- alang-alang mĕgara, inclining toward red
- mĕgabĕr (= mĕgambĕr), color of gambir dye
- mĕtempara, smoky, sooty
- mĕtenggoeli, color of syrup from native sugar
- mĕkĕlaboe, ash-colored

orange
- mĕgara mĕtoewa, dark red
- mĕgara, red
- mĕgara ngoeda, light red
- mĕgara mĕgĕrsing, yellow-red
- mĕgĕrsing, yellow
- mĕgĕrsing mĕtoewa, dark yellow
- mĕgĕrsing ngoeda, light yellow

burnt Sienna was given the following designations in addition to those listed under orange:
- mĕgara mĕrandoel, certainly red

burnt Sienna (*Continued*)
- mĕkĕrahkĕrah, toasted
- alang-alang mĕgĕrsing, inclining toward yellow

chrome yellow
- mĕgĕrsing, yellow
- boenga lĕgolĕgo, color of faded flowers

yellow ocher
- mĕgĕrsing, yellow
- mĕkĕlaboe, ash-colored
- mĕgĕrsing mĕlangĕn, faded yellow
- mĕgĕrsing bĕntar, white-yellow
- koeningĕn, yellow

Van Dyke brown
- mĕgĕrsing mĕtĕmpara, smoky yellow
- mĕtĕmpara, smoky
- mĕgara mĕtoewa, dark red
- mĕkĕrah,[26] toasted
- mĕtĕnggoeli, color of brown-sugar syrup
- mĕgĕrsing mĕtoewa, dark yellow
- mĕgĕrsing ngoeda, light yellow
- koeling mĕtoewa, dark skin color
- mikan, color of dried fish
- alang-alang mĕgara, inclining toward red

malachite green
- mĕratah, green
- mĕratah ngoeda, light green
- mĕratah toewa, dark green
- mĕratah boeloeng soekat, green, as the leaf of soekat (*Colocasia antiquorum*)
- mĕratah mboelan, white-green
- alang-alang mĕratah, inclining toward green
- mĕkĕlaboe, ash-colored

yellowish oil green
- mĕkĕlaboe, ash-colored
- mĕkĕlaboe-kĕlaboe, somewhat ash-colored
- mĕgĕrsing, yellow
- mĕgĕrsing mĕtoewa, dark yellow
- mĕgĕrsing mĕratah, green-yellow
- lego-lego, color of leaves affected by drouth
- mĕratah, green
- mĕratah mĕtoewa, dark green
- alang-alang mĕratah, inclining toward green

blue (spectrum blue and Prussian blue)
- mĕratah, green
- mĕratah ngoeda, light green
- mĕratah mĕtoewa, dark green
- mĕratah mĕlangĕn, faded green
- mĕkĕlaboe, ash-colored

indigo
- biring, black
- mĕratah, green
- mĕratah biring, black-green
- itam, black (Mal.)
- mĕratah mĕtoewa, dark green
- alang-alang biring, tending toward black

violet
- mĕkĕlaboe, ash-colored
- mĕlangĕn-langĕn, somewhat faded
- mĕlangĕn, faded
- boenga rĕbi-rĕbi, (color of) the night flower
- mĕratah bĕntar, whitish green
- mĕratah ngoeda, light green
- mĕratah magĕm-magĕm, dull green
- alang-alang mĕratah, tending toward green
- mĕgara-mĕratah, green-red
- mĕgara, red

violet-slate
- biring, black
- biring ngoeda, light black
- binara, reddish

black
- biring, black

white
- bĕntar, white
- mboelan, white
- poetih, white (Mal.)

[26] It is not unlikely that *kĕrah* is cognate with *kolat*. See discussion of Pardembanan *masam kolat, si kolat, soekelat*, p. 19.

RELATIONSHIPS OF THE CHARACTERISTIC KARO WORDS

The affinities of most of the Karo color words are discussed under the Toba or Malay cognates. For *mĕgara*, see *rara, gara, bara*, p. 28; for *mĕratah*, see *rata*, p. 32; for *mĕkĕlaboe*, see *kĕlaboe*, p. 9; for *biring*, see *birong*, p. 33; for *bĕntar*, see *bontar*, p. 37. Only two important words are characteristic of Karo, *mĕgĕrsing* and *mboelan*.

GERSING, *yellow, orange* — This word is considered as characteristic of Karo because it seems to be more frequently and consistently used in Karo than is the cognate *gorsing* in Toba. Except in Batak clear cognates are lacking, but Javanese *gĕsĕng* and *gosong*, scorched, sunburnt, may be such, especially in view of the use in Toba of a derivative of *gorsing, goemorsing*, in much the sense of the Javanese words. *Gĕrsing*, however, seems to be a compound of two roots which are both sufficiently common and widespread to make the meaning of the word quite clear. *Gĕr* or *gor* has already been discussed under *gerger* (p. 19) and means glowing, burning. *Sing* occurs alone and in compounds where it means light, a ray of light, yellow, etc. Examples are Malagasy *singa*, sun, Nias *sino*, sun, Selung *seng*, light, Gajo *oesing*, yellow and *mĕsing*, to burn, Malay *sinar*, Ibanag and Tagalog *sinag*, ray of light, Dayak *singah*, flame, Karo *djingar*, flaming, Makassar *singara*, daylight, Mota *'singa, singar*, to give off light, Fiji *singa*, daylight, sunlight, Samoan *senga*, to shine, and *sina-sina*, white. Some of these words are related by Schmidt (59) to Mon-Khmer words, of which the one most obviously similar is Santal *sin*, sun, day. Joustra (33) gives a Karo word that exists only in the language of incantations, etc., and is therefore quite likely to be of Toba origin, *singgargar*. It occurs in the expression *matawari singgargar*, meaning the morning sun. It appears to consist of the same elements as *gĕrsing*, in reverse order. Two other Karo words add to the evidence that *sing* means sun or light. One is *singkĕm* or *tjingkam*, shadow of a cloud, literally, darkening of the sun. The other, *singĕp*, in the phrase *singĕp-gĕlap*, between light and dark, means also darkening of the sun. Finally, there is a Malay word *sengseng* or *singsing* that has two apparently unrelated meanings,

The first is to tuck up a garment, reef a sail, etc., the second, daybreak or dawn, which Wilkinson explains as metaphorical and poetic, a rolling away of the darkness. It seems more likely that *sengseng* refers to the first light of dawn, and that in the expression *fajar* (Arabic, daybreak) *menyengseng* the Malay gives the meaning of a rare literary Arabic word, thus dawn breaks into light, rather than daybreak rolls away (the darkness).[27] Words that persist in a single expression in Malay are likely to be explained incorrectly. Even if all the words cited do not prove to be placed correctly, there is sufficient evidence that *sing* or *singa* is an old word for sun, which has given derivatives meaning light and yellow, just as another ancient root, *ra*, meaning sun, has given rise to many of the words for red. In conclusion, it may be suggested that Malay *djingga* or *djinggo*, orange or vermilion, a word of entirely obscure affinity, may possibly be traceable to *sing* and *ra* or *gor*.

MBOELAN, *white* — The common use of an adjectival form of the word for moon is one of the most interesting features of Karo color nomenclature. In Karo the word has undergone no changes and is therefore undisguised, in sharp contrast to the Pardembanan form *na lopak*, which at first sight is not recognizable as a word of the moon series. (See discussion of the latter, p. 20).

NOTES ON THE KARO VOCABULARY

Brandstetter (11), taking exception to the pronouncement of Warneck (70) that the Batak have no color sense, lists the Karo color words, apparently from Joustra's dictionary (33), and includes three, *rĕngge*, *hino*, and *ngida*, which do not occur in the foregoing lists. There is no doubt that all might be used occasionally with a color sense, but that they are other than of very minor significance in the color vocabulary does not seem likely. The first, *rĕngge*, seems to be a variant of *rĕnggĕt*, which means parti-colored, or iridescent, or changeable. According to the dictionary, *rĕngge* applies to the light brown of something that is cooked. A color change is therefore the connotation of the word, rather than

[27] This explanation is strengthened by the exactly parallel situation with regard to Karo *djingar*. (See discussion under Mal. *djinggo*, p. 9, footnote.)

light brown (*"hellbraun"*) specifically, which is all that Brandstetter gives by way of definition. The second word, *hino*, is defined by Brandstetter as misty blue (*"duftig blau"*), but properly the emphasis should be on the misty. It is not essential that the conception of blueness should be read into the definition at all, for the idea conveyed by the word is low visibility from distance or smoke or mist. The third word is *ngida*, for which Brandstetter gives the meaning light green. This meaning is derived. The primary meaning, as the word is applied to the young soft leaves of plants used for greens (*boeloeng ngida*), has reference to the consistency of the boiled leaves, which are not *ngida*, regardless of how green they are, unless they will cook down to a soft mucilaginous mass. The word also describes the consistency of fat. By the elimination of these three words the Karo color vocabulary is considerably reduced, and is left in the same condition as the Toba, with a single word, *měratah*, generally applicable to lighter shades of green and blue, and *biring* applying to both black and dark blue. Karo is likewise very vague in the use of *kělaboe*, gray, which applies to almost any partially neutralized color of low luminosity.

GENERAL DISCUSSION AND CONCLUSIONS

The writer believes that most of the fundamental and widespread Indonesian color words may be traced to the names of things in which color is a prominent characteristic. Elsewhere the relationship or identity in many of the languages of the words for Curcuma, which has a brilliant yellow rhizome, and for the color yellow itself, has been pointed out (Bartlett, 4).[28]

More ancient than the words for yellow (Mal. *koening* and cognates) derived from the names of Curcuma are names for

[28] Since the article referred to was published the writer has become acquainted with Brandstetter's similar conclusion (11). He says, "Die genannten Bugischen Termini bezeichnen nun nur die Farbe als Eigenschaft, sie nennen nicht zugleich einen Gegenstand, der die betreffende Farbe an sich hat. Allerdings in gewissen indonesischen Sprachen bezeichnet ein und dasselbe Wort, ohne Veränderung, 'Kurkuma' und 'gelb'; dies gilt z. B. von Tontemboanischem '*kuniq*.' Im Mal. dagegen ist 'gelb' *koening* und 'Kurkuma' *kunyit*. Der Terminus Grau ist in mehreren indonesischen Sprachen eine Ableitung vom Worte Asche oder Staub, so dass 'grau' wörtlich 'aschig' ist: Gemein IN *awu* 'Asche, Staub,' Tontb. *awu-awun* 'grau.'"

both red and yellow derived from at least two roots, meaning sun, namely, *ra* and *sing*. These roots are traced in the Batak and Malay words *rara*, *merah*, etc., red, and Batak *gĕrsing* and *gorsing*, yellow. Closely related or identical to roots for sun are those meaning red-hot or glowing, and these also give rise to color words, such as Batak *bara*, *gerger* and *gĕrsing*. The words for blood seem to be derived from the primitive words for red, and to have given, in turn, another series of words for red so slightly different from the older ones as often to become assimilated with them. The word for glowing seems to have given rise to a word for charcoal (or at any rate there is a close relation between the words), and the latter has given words for black in Batak and other languages which closely resemble some of the words for red. More ancient, probably, are the words for black belonging to a series, including Mal. *itam*, which are derived from a root meaning darkness or night.

The words for white are various. One series which is widespread has Mal. *putih* as a typical member. It has not been proved to have any more concrete meaning than white. There are many languages, however, of which Karo Batak is one, in which the word for moon gives rise to the word for white, just as the word for sun gives words for red and yellow.

Modes of expressing the ideas orange and purple occur sporadically in Indonesian languages, but have never been so necessary that they have come into general use. Distinctive words do not, for example, occur in Batak but are found in Malay. No general or very widespread word for brown has ever come into use, but the concept brown has been found useful by many peoples, with the result that local words are not uncommon. In Batak they come from the color of cooked or toasted food (e.g., Karo *mĕkĕrah-kĕrah*), the color of the skin (Pardembanan *hoelikkoeling*), the color of native sugar (Karo *mĕtenggoeli*), the color of smoked objects (Karo *mĕtempara*), etc. The most common one seems to refer both to the taste and color of scorched food (*masam kolat*, *si kolat*, etc., in Malay and Batak dialects).

In most Indonesian languages there is a word, derived from the word for ashes, to denote gray or grayish colors.

Up to this point the color nomenclature of Batak, Malay, and related languages is not noticeably deficient — no more so, one may suspect, than it was in most European languages not so very long ago, to judge from the large number of borrowed words in most languages. When we consider the condition with regard to blue and green, however, there seems distinct evidence that the Indonesian psychology is quite different from our own. Words for black apply to dark blue and words for green to light blue. After words for blue are introduced, they are sometimes used quite correctly, but in many instances as vaguely as the indigenous word for green. In his careful studies of color nomenclature and recognition among the Minangkabau, Maas (41) found that *idjau* and *biru* were both used in the sense of green or blue, adoption of new words not securing precision of application.

The Malay word for green, *idjo*, is a member of a widely distributed (but not General Indonesian) series of words meaning green and blue. A more fundamental meaning is not known. The Batak word *rata* means fresh or flat, as well as green, and belongs to an even less widely distributed series, as far as color nomenclature is concerned. Both *rata* and *idjo*, there can be no doubt, applied in the past to the whole color range from green through blue and sometimes violet. Even now unschooled Batak and Malay speakers so use the words. Often a speaker who uses an introduced word for blue, and restricts the indigenous term to the meaning green, will, when expressing the idea purple by a compound corresponding to red-blue, say red-green instead.

As a result of his work in Torres Straits, Rivers (53) concluded that the color vision of the Papuans and of certain other races examined was certainly not of the same type as that of Europeans. He found that the color vision of the Papuan was characterized by a certain degree of insensitiveness to blue (and probably green) as compared with that of Europeans. He regarded the philological argument, the defect of language in not having separate words for blue and green, as not a very strong one, yet could not help being impressed by finding in the dialects he studied either no word for blue or an indefinite one, whereas the nomenclature for red, and generally for yellow, was extremely

definite. Moreover, he found intelligent natives regarding it as perfectly natural to apply the same name to the brilliant blue of sky and sea as to the deepest black. In Mabuig, where every color was compared with some natural object having the same hue or shade, generally with a high degree of appreciation of hue and shade, a brilliant saturated blue would be compared with the color of dirty water or to the darkness of night. In tests with Holmgren's wools and with the tintometer he got definite evidence that his subjects could certainly see and distinguish blue, but that there was a certain degree of insensitiveness to this color in direct vision. On the contrary, the natives of Torres Straits recognized a saturated blue readily in indirect vision, which suggested that their pecularities of vision were possibly a function purely of retinal pigmentation and due to a greater comparative absorption of blue (and green) rays by the pigment of the region of central vision.

Rivers suggested that other factors besides physiological insensitiveness were concerned with determining the characteristic features of primitive color nomenclature, among them (*a*) the distribution of pigments in nature, (*b*) the psychological fact that even to European eyes there is a closer resemblance between blue and black, or green and black, than between red, or yellow, and black, and (*c*) the absence in primitive people of an æsthetic interest in nature.

"If the savage has a special name for every colored object," Rivers says, "he will not require names for the abstract idea of color. It is possible that it is only when he begins to use pigments that he begins to require names for colors. There can be very little doubt that the earliest pigments used by men were red, possibly as a substitute for the red that has so prominent a place in all savage rites and ceremonies." The argument is continued by showing that in Torres Straits there are good red and yellow pigments but no green or satisfactory blue. The situation is different for the Batak, who have exactly the peculiarities of nomenclature ascribed to the Papuan, for they have probably known and used indigo for hundreds of years. Nevertheless their defect of color nomenclature has remained, and is only

being modified by continuous European contact. The three important colors in Batak ceremony and ornament were white, red and black, indigo being an acceptable substitute for the black.

The linguistic evidence would seem to show that whatever the factors may be that are responsible for defective color nomenclature among the Papuans, they are likewise operative among the Indonesians. The writer is not greatly impressed by the argument that distribution in nature of tangible pigments is an important factor, nor by the argument that primitive man lacks æsthetic interest in nature. Rivers says: "The blue of the sky, the green and blue of the sea, and the general green color of vegetation do not appear to interest the savage. It is the individual objects which he can take in his hands and use in his daily life which interest him, and it is to the attributes of these that names are given." If so, why is it that only a few words in the fundamental color vocabulary of Batak and Malay, such as *hoenik* or *koening*, yellow, and the words for black from charcoal, are the names of pigments or of tangible things? Most of the words for red and yellow come from words for the sun. Even if some words for red may come from blood, the word for blood itself probably comes from earlier words for red that originally meant the sun, or the abstraction glowing. Moreover, some of the commonest words for white come from the word for moon, or cannot be traced from an abstract to a concrete meaning.

The psychological aspect of race difference would seem to be worthy of more attention than it has received. Language must to a certain extent reflect race psychology. It is from this standpoint that Rivers's work on color vision is especially interesting, and that the writer's observations on the Batak should be of some supplementary value.

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THE CARVINGS OF THE PAIWAN OF FORMOSA*

HARLEY HARRIS BARTLETT

DURING a recent botanical trip in Formosa the writer spent part of two days in Raishya, one of the most populous villages of the Paiwan group of aborigines. The Paiwan are distinctive as the most artistic of the aborigines. The Taiyal expend their artistic efforts mainly on clothing, aside from which the carving of their tobacco pipes and the incision of designs on small personal objects made of bamboo are the chief evidences of a creative art instinct. Among the Ami, the Tsuo, and the Bunun most of the art expression, as far as is obvious to a hurried traveler, is in the way of personal adornment. The Paiwan, on the contrary, decorate not only small personal possessions but also their houses. The motives of their distinctive carvings are derived from the head cult, which is associated with fertility rites and ancestor worship. We may infer, from the house decorations, that head-hunting played a part in the dedication of a new house.

The only visible part of a Raishya house which is of wood is the heavy beam along the top of the slate wall, which supports the enormously heavy slate roof. This is often elaborately carved with human heads, snakes, deer, and nude human figures, male and female. The sitting platforms before the houses of the head men are marked by an upright stone pillar and a tree. The writer did not see carved pillars in Raishya, but they occur in the Paiwan district and are figured by Ishii [1] and

* Paper from the Department of Botany of the University of Michigan, No. 293.

[1] Ishii, S., *Report on the Control of the Aborigines in Formosa.* Taihoku, 1911. (See the second and third unnumbered plates following p. 30.) This valuable book was published anonymously by the Bureau of Aboriginal Affairs, Government of Formosa. It is credited to Ishii by W. J. Perry, The *Megalithic Culture of Indonesia,* Manchester, 1918.

McGovern.[2] Ishii's plates illustrate an erect stone slab, higher than a man, on which are incised two snakes and a human head, apparently decorated with a cap and two feathers. The slab figured by Mrs. McGovern shows an entire human figure with the head encircled by a snake. The snake has no head, and the identification might be questioned if it were not for the fact that it is depicted in a characteristic, conventional way with diamonds and triangles. The house in the background of the pillar has the roof-beam decorated with coiled snakes and with heads represented as though strung together by tying braids of hair together, or by impaling them through the cheeks.

Inside the houses at Raishya the great slabs of slate forming the walls have furnished a place for the making of petroglyphs, of which I saw only one specimen, but that a very interesting one. It was in a very small almost subterranean chamber into which only a beam of light entered through a crack. Since I was not equipped with flashlight, and the space was very cramped, it was very difficult to get a picture, but two long exposures were made. The two pictures, fitted together, have given Plate III. The same house which contained this petroglyph had been built over an older structure of which the carved roof-beams still remained. It was probably the oldest wood carving seen, and was remarkable in that it represented the heads in high relief. All others seen were in very low relief, or the design was made by simple incision of outlines in the wood, which were intensified by the application of white, black and red pigments.

The carving of a roof-beam is in general symmetrically developed. At the center are two human figures, male and female, either feet to feet or head to head, or there may be figures of two deer. Human figures are always represented in front view, and not at all modified to adapt them to their horizontal position. They are simply bilaterally symmetrical figures placed in a horizontal instead of a vertical position. Deer are represented in profile. Figures of both men and deer are highly conventional.

[2] McGovern, Janet B. Montgomery, *Unter den Kopfjägern auf Formosa.* Stuttgart, 1923. (The incised pillar is shown in Figure 16; a very fine carved roof-beam with male and female figures in Figure 11.)

The human figures show the sex organs with sufficient emphasis to indicate clearly that they are the equivalent of the fertility charms which exist throughout Indonesia. The figures of the deer are placed head to head and between them is sheltered a little deer, so that here too there is a fertility charm. On each side of the pair of central figures is a row of heads over which are draped snakes, or there are human heads alternating in some definite order with snakes.

More detailed observations on the house beams will be found in the description of the plates.

Throughout Indonesia there is, or was, a definite connection between head-hunting and fertility rites. A head had to be taken by a man before he could marry. The increase of the people was insured by the ceremonies of which the actual getting of the head was the beginning. From a negative standpoint, the head ceremonies prevented the decrease of the people by pestilence or war. The head ceremonies were necessary in order to secure a good crop.

The making of pairs of male and female figures is, in Indonesia, an indication that such figures are, or have been, used as fertility charms. Not only do the Paiwan associate male and female figures on their houses with human heads, but they also make such figures on the sheaths of their head knives, and carve entirely independent little figures which are quite the counterpart of the fertility charms of the Batak of Sumatra. Some of the Paiwan figures are shown in Plates X and XI. The reader will note the striking similarity of the small Paiwan carvings to those of the Ifugao of Luzon, so abundantly represented in our museums.

The association of snakes in Paiwan art with the fertility figures and the heads is shown not only by the writer's photographs but also by the figures already published by Ishii and McGovern, previously cited. We find this association not only in the large carvings on the pillars and houses, but also on such small objects as powder horns and knife handles. (Notice the coiled snake on the powder horn in Plate IX, Figure 3.) The handles of the old knives shown on Plate IX are carved with both snakes and heads. It is possible that an explanation of the asso-

ciation of the snake with the head cult may have been given in the voluminous Japanese literature on the aborigines of Formosa.[3] If not, the matter is more properly a topic for direct inquiry by someone on the ground than for speculation, and will doubtless receive the attention it deserves from some local investigator. The art of the Paiwan is so unified, so distinctive, and made up of so few elements, that the association of the snake with the heads and fertility figures cannot be a mere accident.[4]

University of Michigan

DESCRIPTIONS OF PLATES

PLATE I

The house of the ancestors at Raishya. This house was said by the natives to be the oldest in Raishya, and to be looked upon with veneration on that account. It has the stone-flagged platform where the people sit in the shade at their various occupations, the erect monolith which signifies that it is a chief's house, and the old tree, which is associated with the spirits of the ancestors. The house at the left is more modern. The carvings of its roof-beam are shown in Plates V and VI, Fig. 1.

PLATE II

Fig. 1. Entrance to a slate house in Raishya. The old carved roof-beam is obscured by the line of lower jaw bones of animals killed in the chase. The

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[3] The Formosan Government has published extensive reports, some of them with excellent illustrations, on the aborigines of Taiwan. These have not, however, been drawn upon by European writers, with one possible exception, and in this case the sources of the information have not been disclosed by the author, who is very vague in distinguishing between first-hand and second-hand information.

[4] A Philippine case of the ceremonial equivalence of a snake with a human being is recorded by Moss. The *bindian* ceremony of the Baguias Kankanay, which is the same as the *bindayan* of the Kabayan Nabaloi, corresponds to the head dance of the Igorot to the north of them. In Kabayan a dummy head is carved to represent the head of a person, but in Baguias the carving represents the head of a snake, and the *bindian* song celebrates the deeds of heroes who slew two large snakes that had killed many persons. The basis of the head cult is the propitiation of the spirit of the person killed, and involves the adoption of the spirit as a protector and helper of the killers. The Paiwan carvings suggest this basic idea, rather than the celebration of the exploits of the killer, but nevertheless there is probably some historical connection to account for the association of snakes with the head ceremonies in both Formosa and the Philippines. (See Moss, C. R., *Kankanay Ceremonies*. Univ. Calif. Publ. Amer. Arch. and Ethnol., 15 : 343–384. 1920.)

preservation of lower jaw bones of animals is found throughout Indonesia. FIG. 2. Paiwan children playing under the tree on a slate-paved house platform. Note the garlands of flowers worn around the head — a distinctive trait of the Paiwan, children and adults, men and women.

PLATE III

Carved beam of an old house (or granary?) now entirely inclosed within a house built around the older structure. The heads are carved in high relief and are separated from each other by a concentric ring design, which may possibly be an exceedingly conventionalized snake. (Note the sheaves of millet piled on the roof above the carved beam.)

PLATE IV

Petroglyph incised on large slate slab forming part of the wall of the same house where the beam shown in Plate III was found. It was in a semi-subterranean room, dark except for a ray of light that glanced obliquely across the wall from a crack, fortunately illuminating most of the carving. On account of the narrow quarters the picture had to be taken in two parts, pieced together in this plate. The entire carving represented a central figure with a head on each side. All three figures are shown with what appear to be elaborate head-dresses, perhaps of feathers or other ornaments.

PLATE V

Left hand part of the decoration of the roof-beam of the house shown at the left in Plate I. FIGS. 1, 2, and 3 follow serially from left to right, and are followed by Plate VI, Fig. 1. On right and left of the center are human heads draped with snakes, the snakes having heads at both ends. Each pair of human heads alternates with a coiled single-headed snake. The center shows two deer, nose to nose, sheltering between them a small deer. In this plate and those that follow the use of the triangle and diamond in building up the design will be noticed. Similar designs are common in Sumatra and elsewhere in Indonesia.

PLATE VI

FIG. 1. Right hand part of the roof-beam shown in Plate V. From analogy with similar carvings elsewhere in Indonesia, in which pairs of male and female figures constitute a fertility charm, it is presumed that they have the same function here. They may likewise represent the ancestors. FIG. 2. Old roof-beam with a symmetrical design, the center of which consists of two single-headed snakes coiled in opposite directions. At the sides are represented curious festoons of human heads connected as though they had been impaled through the cheeks. The design is not unique, being found on other houses at Raishya, on Paiwan knife sheaths, and on sculptured house-beams figured by McGovern, who does not give localities. (The carvings of the beam obscured by jaw bones in Plate II, Fig. 1, are of the same description.)

PLATE VII

FIGS. 1, 2, and 3 follow serially from left to right and illustrate a roof-beam of unusually diversified artistry. The design has human heads without snakes,

human heads draped with snakes having heads at both ends, one-headed snakes both coiled and naturalistically wriggling, and human heads draped with snakes which both at head and tail end in conventionalized human hands. (The interpretation of the hands as such is based upon the representation of hands in Plate VIII, where the design lacks snakes but has human arms instead.) At the extreme right in Fig. 3 will be seen the feet of a horizontal human figure similar to those in Plate VI, Fig. 1, but placed head to head with its mate.

PLATE VIII

FIGS. 1 and 2 follow serially, and illustrate a unique roof-beam in which none of the heads is encircled by snakes. Instead, there are uplifted human arms at either side of the heads. The writer interprets this as a charm to insure that the spirits of the persons decapitated in behalf of the prosperity of the house shall not allow the enormously heavy roof to collapse. FIG. 3 shows a part of a very old, weathered roof-beam, without pigment, on which the heads are all draped with double-headed snakes.

PLATE IX

FIGS. 1 and 2 illustrate the front and back of two of the old head knives of the Paiwan. It is customary for all of the Formosan aborigines to make the knife sheath of wood on one side only, the other being of ornamentally twisted brass wire. The carving of the sheaths shows exactly the same motives as the larger carvings of the houses, namely, male and female figures (in some cases the sex is not indicated) and heads. The handles are either embossed to make a good grip, in a purely geometrical design, or are carved with minute heads and snakes. Fig. 3 shows a collection of carved ethnographic specimens from Raishya in the collection of a Japanese gentleman in Formosa. It includes a knife (similar to those in Figs. 1 and 2), one of the double wooden millet-beer drinking cups, and five spoons very similar to those made by the Ifugao of Luzon.

PLATE X

Rubbings of the knife sheaths showing the designs more clearly than the photographs in Plate IX. FIGS. 1 and 2 are from the same knife; likewise FIGS. 3 and 4. (Note the festoon of heads in Fig. 4.)

PLATE XI

FIG. 1. Minor carved objects from Raishya, obtained by the writer. The nude male and female figures are presumed to be a fertility charm. The spoons are startlingly like those of the Ifugao. FIG. 2. Part of the collection of Mr. Mitsui, the Japanese officer in charge of the Raishya district. The carving at the center is in the flat conventional style of the house-beams and knife sheaths. The others, again, are remarkably similar to Ifugao carvings. It is presumed that during the migration period, while the Paiwan still maintained connections with Luzon, there were people near the coast in Luzon, now merged into the present Christian population, who had an art similar to that of the Paiwan and the Ifugao.

PLATE I

Fig. 1

Fig. 2

PLATE III

PLATE IV

PLATE V

FIG. 1

FIG. 2

FIG. 3

FIG. 1

FIG. 2

FIG. 1

FIG. 2

FIG. 3

FIG. 1

FIG. 2

FIG. 3

PLATE IX

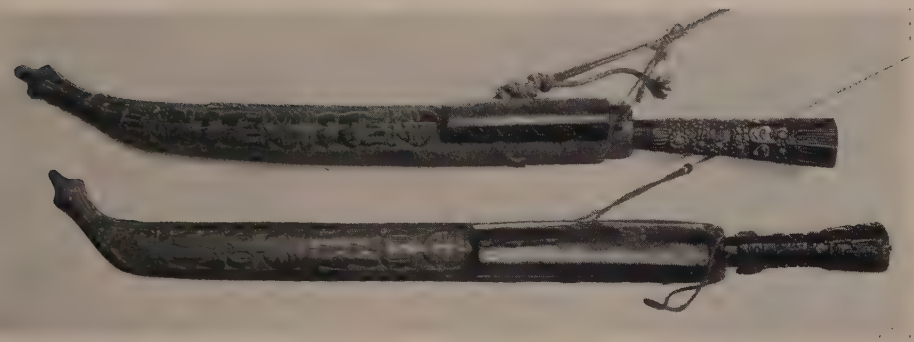

FIG. 1

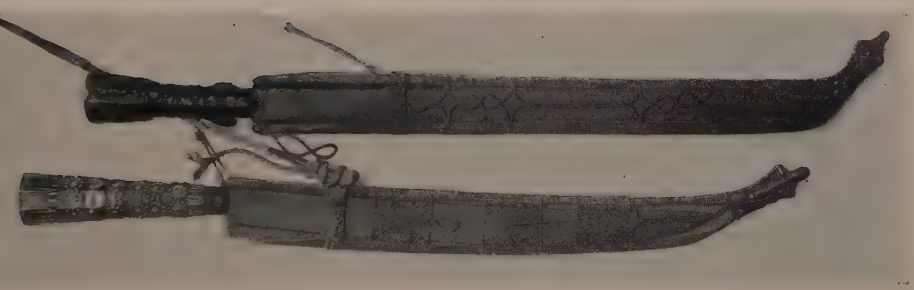

FIG. 2

FIG. 3

PLATE X

FIG. 1

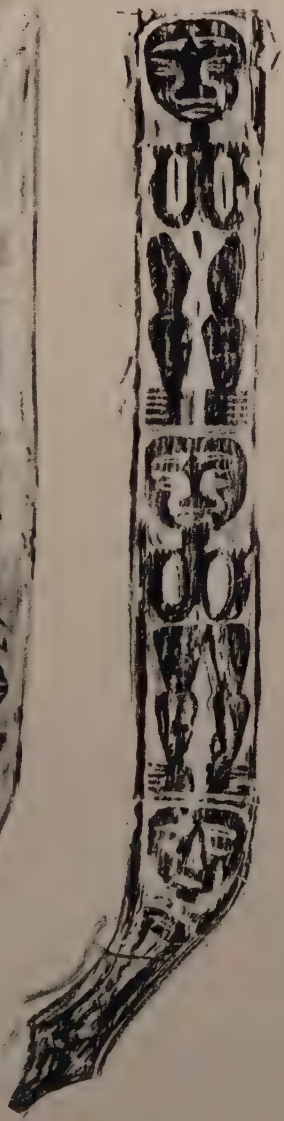

FIG. 3

FIG. 4

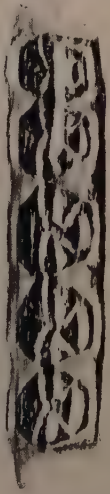

FIG. 2

PLATE XI

FIG. 1

FIG. 2

HOUSE TYPES IN AFRICA

STANLEY D. DODGE

FROM the dry wastes of the Sahara to the area of European settlement in the south, there is a great variety of houses in Africa. Classification almost leads to despair. The Sahara, with a practical absence of human beings and beyond which extra-African influences prevail on the Mediterranean littoral, and South Africa, the home of Boer and English, mark the limits of what may be called *purely* African in house type. Even in the area between, however, non-African influences are at work, multiplying the varieties of shelter constructed by the inhabitants of the area. In spite of house individuality, nevertheless, classes of houses may be established in which the similarities from house to house, from tribe to tribe, are more important, geographically and anthropologically, than the differences. These classes occupy more or less distinct areas. Throughout the rain-forest area of the Congo and of the Guinea Coast, rectangular houses built of stout poles are found. In the north, beyond the forest area, the beehive reed or grass hut occurs, mixed with other types, west of Lake Chad, and the cylindrical hut, of the same material, really a modification of the beehive, occupies most of the area east of the Shari-Chad Basin. In South Africa various modifications of the beehive type of house are found. Throughout Central Africa there is a correspondence in general, although perhaps not always in detail, between house type and vegetation. Tribal and individual differences mark detail, but locally available material, fashionable conveniently into a shelter, practically dictates the form of the house.

Taking Central Africa as a whole, the dominant house type is the beehive hut, more or less modified. It is generally made of grass or reeds, and hence occurs chiefly outside forested Congo-

land. Its principal area of distribution is the Savanna and semi-arid grassland of North Africa, the region called the Sudan. It occurs also in East Africa, on the grassy highland, and in South Africa on the Rhodesian grasslands. In forested Africa the beehive, greatly modified, occurs where suitable timber is not available because of the massiveness of the trees or because of local absence of forest. For most of the forested area the house is one of posts and poles, rectangular and thatched with grass, palm branches, or leaves. In the Kalahari no formal framework is made in the construction of shelters. Local materials, even living bushes, are loosely woven together to make what may pass for a hut. Thus, in Central Africa, the beehive hut in various forms occurs throughout the area. In addition to general dominance the beehive hut has areas in which it occurs especially. There are also three other areas, in which, besides the beehive hut, other forms occur, each dominant for a part of the general area. These three areas are (1) that of the rectangular hut, (2) that of the cylindrical hut, and (3) that of the crudely constructed wattle hut.

It will be seen that each group corresponds, in general, to a vegetation region. Within the habitat-group area the prevailing building material dictates, in a sense, the form of the building and is, thus, more important than local tribal differences which may, however, modify the details of construction and ornamentation. The most striking correspondence between house form and vegetation is found in the case of the rectangular hut of Central Africa. In the Congo Basin, the roof is the most important part of the shelter. Where the range of temperature is within narrow limits at a high degree, protection against cold, the function of the wall in part, is not necessary. Congo temperatures vary rarely more than five degrees Fahrenheit from season to season and between day and night in any season, and they are usually somewhat higher than sixty-four degrees Fahrenheit. Rain, on the other hand, is copious. The shelter is constructed to protect against rain, and the roof assumes an importance that it does not have in dry regions like Egypt, where it may be absent. In Congoland, the roof is constructed of poles

cut of nearly equal length and laid side by side on the supporting wall timbers. The result is an oblong or square building.

The rectangular house, usually square or slightly oblong, is

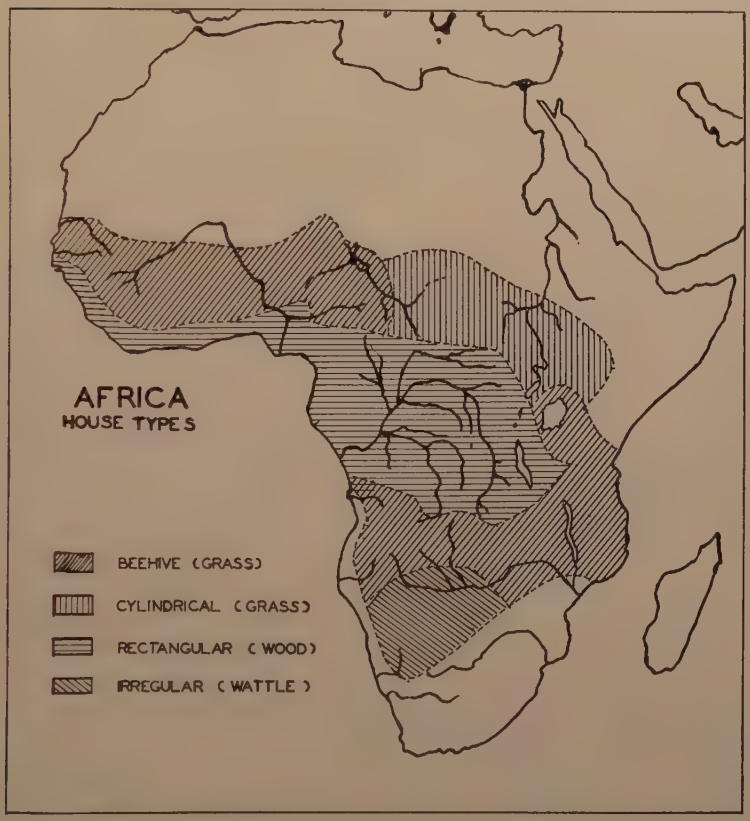

FIG. 1. Map showing areas in which various types of African houses are found

found not only in Congoland proper,[1] but on the forested slopes of Elgon,[2] in what is now Kenya Colony, among the Kondé,[3] of western Tanganyika, the former German East Africa, and

[1] G. Cyril Claridge, *Wild Bush Tribes of Tropical Africa*, p. 64.
[2] J. Roscoe, *The Bagesu*, p. 19.
[3] D. R. Mackensie, *The Spirit Ridden Kondé*, p. 32.

westward across the Congo Basin to Guinea. In Nigeria, Dahomey, Ashanti, and elsewhere west to Sierra Leone, there is a sharp line separating the rectangular hut of the equatorial rainforest from the grass and mud hut of the region of scanty forest to the north.[4] Throughout the Guinea region the forest is chiefly on the lowlands, ceasing at the escarpment that forms the edge of the African plateau a hundred and fifty miles inland. On the western Sudan portion of the plateau the climate is drier than on the lowland, forest is rarer, and the house type differs accordingly. The escarpment limits the rectangular house,[5] exerting its influence in this case indirectly through climate and vegetation. Elsewhere on the borders of the area in which the oblong house is dominant, sharp transitions to other house types do not occur;[6] the replacement of the forest by grassland is more gradual where a noticeable physiographic feature does not intervene. For the most part, however, beyond the limits of the forest, the rectangular house is not found in Central Africa. There is a close correspondence between vegetation and house type, a correspondence in which the available material determines, especially through the construction of the roof, the general shape of the house.

On the boundaries of the oblong hut area, especially in the vicinity of Elgon, north of Victoria Nyanza, the house of wood is being replaced by the house of reed or grass.[7] Various influences are at work in this connection. The chief reason is that Elgon is a forested island rising in the midst of an unforested plain. On the wooded slopes of the mountain oblong hut dwellers have lived in contact with more warlike plains nomads, the Masai in particular. With the advent in the recent past of British settlers, the plainsmen have been thrown into a ferment of unrest. Although partially quelled at the present time, the unrest lingers in tribal and individual movements, which result in the alteration of house types. Weaker peoples have been

[4] R. A. Freeman, *Travels and Life in Ashanti and Jaman*, p. 213.
[5] C. J. Meek, *The Northern Tribes of Nigeria*, p. 38.
[6] F. H. Melland, *In Witch Bound Africa*, p. 24.
[7] J. Roscoe, *op. cit.*, p. 64.

pushed back into the depths of the forest, higher up the mountain slopes, and their wooden houses, fallen to disuse, are replaced by the grass or reed huts familiar to the peoples who have displaced them. It must not be forgotten that the occupation of Kenya by the British has made the permanence of the native villages less sure; contact with the British throughout Africa has loosed strict village ties and has brought about a greater freedom of movement from place to place, with serious social consequences, and not without effect on house-form characteristics. With the possibility of the evacuation of villages by considerable portions of the population because of the exigencies of the labor market, forced or otherwise, or with the possibility of complete desertion in face of European advance in East Africa, less substantial dwellings fulfill the needs of the local Negro population as well as, if not better than, the more laboriously constructed rectangular huts. Alterations in the tribal and social complexion of East Africa, subsequent to the advent of the British and Dutch, have found their geographical expression in alterations in the house type, where, as on Elgon, the rectangular wooden hut has been partially replaced by the conical or hemispherical beehive.[8]

Here and there in the Congo the rectangular hut takes on special characteristics. Several huts, perhaps the whole village, may be gathered under one roof.[9] This is called a *tembe*, a word perhaps not unrelated to the Swahili word for elephant, *tembo*. It presents an aspect of thatch spread out on a forest of posts, subdivided beneath to form separate compartments, originally individual huts.

Exceptions to the rectangularity of house type there are. Throughout the Congo Basin and on its margins, but within the area dominated by the oblong house, there occur other types of hut, notably various modifications of what may be called the dominant type for Central Africa as a whole, namely the beehive hut.

The beehive hut and its close relative, the cylindrical hut,

[8] G. St. J. Orde Browne, *The Vanishing Tribes of Kenya*, p. 110.
[9] W. C. Willoughby, *Race Problems in the New Africa*, p. 120.

occur throughout the greater part of Africa, since they even penetrate the forested Congo Basin. In its simplest form, the beehive is merely a dome of thatch constructed with a framework of wattle or coarse reeds. Raised on a low wall, the beehive becomes a cylinder, for the cylindrical hut is frequently nothing more than a dome modified in this way, although the roof may sometimes be conical rather than hemispherical. The shape of the hut, whether beehive or cylinder, depends upon the exigencies of locally available material. In Congoland, where the trees are too large for convenient felling for house construction purposes and where the available thatch, for the construction of a beehive, is for the most part relatively small leaves, rather than the large leaves of the palm tree, the size of the hut and its shape must conform to the local building materials. The piling up of small leaves, to shed rain, must be in a nearly vertical wall, tapering gradually to a point, for otherwise heavy rain would beat the layers of leaves apart.[10] Lianas are employed to make the whole compact and more or less durable. The sharply conical beehive is perhaps an extreme type, made necessary by the quality of the building material at hand, but it suggests the variety that may occur within the type, and it shows the way in which an extra-sylvan house type may occur within the confines of the forest itself.

The principal home of the beehive and cylinder huts is in the grassland and half-grass, half-forest areas north[11] and south of Congoland. From Lake Chad westward to Cape Verde, north of the Guinea escarpment and south of the desert, the beehive hut is dominant,[12] as it is in South Africa and parts of Kenya and Tanganyika.[13] The prevailing vegetation, reeds or coarse grass, suggests the weaving together of these plants, in their respective areas, to form the shelter. To a framework of young trees or branches, thatch is variously bound, forming a compact, waterproof hut.[14] A hole is left through which the occupant

[10] Sievers-Hahn, *Afrika*, p. 285
[11] Cf. J. Greenwood, *Curiosities of Savage Life*, p. 401.
[12] C. J. Meek, *op. cit.*, p. 35.
[13] J. Roscoe, *op. cit.*, p. 19.
[14] C. J. Meek, *op. cit.*, p. 35.

may crawl to reach the dark interior. There seem to be two principal methods of construction. In one the builders, after observing the appropriate tabus, start at the top, binding reeds to a small circle of grass, and gradually enlarge the circle, raising it till the right size and height are obtained.[15] In the other, a framework of poles is constructed; poles, set in a circle, are bent towards and fastened at the center; and to this framework, matting or bunches of grass are attached until the requisite strength is obtained.[16] Obviously the latter method occurs in those parts of the grassland where saplings are available. The result of either method of construction is a hemispherical or dome-shaped hut, called by Europeans, beehive.

From Bornu to Sokato, west of Lake Chad, the infiltration of various peoples, chiefly from the east, even perhaps from Upper Egypt and Abyssinia, the subjection of the country by outsiders, and the setting up of various kingdoms and empires, before the European occupation, have led to a multiplicity of house types that seem to negate the statement that the beehive is the dominant pattern. Here and there cylindrical huts are found, and the civilized towns, reflecting the architecture of Egypt, have rectangular houses of adobe brick.[17] These, however, are in the northern, drier portion of Nigeria and may be included with the dominant architecture of Aïr. In the Nigerian area of the beehive hut, too, clay is sometimes a component material, especially where a low sill, or wall, of clay, converting the beehive into a semi-cylindrical hut,[18] is desirable as a precaution against floods, which, during the rainy season, spread out over a ground incapable of absorbing them.

South of the Congo, the beehive hut is of various sizes, from fifteen to twenty feet in diameter,[19] and correspondingly high, to five or six feet in diameter. [20] This depends upon the local

[15] J. Roscoe, *op. cit.*, p. 64.
[16] C. J. Meek, *op. cit.*, p. 34.
[17] *Ibid.*, p. 39.
[18] *Ibid.*, p. 35.
[19] C. Gouldsbury and H. Sheane, *The Great Plateau of Northern Rhodesia*, p. 277.
[20] R. T. Coryndon, *The Lango*, p. 73.

materials for construction. Where poles of sufficient length are obtainable, as in Tanganyika and southward about Nyassa,[21] the houses are large, but they are constructed similarly to those west of Chad, elsewhere smaller houses prevail.

The principal range of the cylinder house is from Lake Chad and the Shari Basin eastward to the Anglo-Egyptian Sudan.[22] The mud wall, making the cylinder, is a necessity in the low lands of the upper Nile, and the dominant architectural note comes thence. The circularity is a function of the roof which is constructed in the manner of the beehive. In addition the region is somewhat drier, and the roof is less important than it is west of Chad. The protecting wall, circular in outline, gives form to the house, rather than the roof, which has a less important rôle.

Minor types of house occur almost everywhere in Africa. A noteworthy minor type is the wattle house, woven usually of small branches of thorn bush or of other woody plants.[23] The skeleton of wattle is, perhaps, covered with grass, as a padding, and the whole made weatherproof by a layer of skins. Crude constructions of this type, in which living bushes are partly worked for a framework for the shelter, are found in the Bushman area of South Africa,[24] in the Kalahari and along its margins. Low in the cultural scale, the Bushman finds adequate shelter in a hut that sometimes shows less art than is displayed by many birds in the construction of nests.[25] Other examples of this type of hut, better constructed than that of the Bushmen, occur in East Africa. In this area there are skins from domestic cattle, or wild game, grass, and wattle. The women of the tribes utilizing this method of shelter-construction are adepts in securing the maximum of serviceability from materials that would seem inadequate for weatherproof results.

Throughout Central Africa, the house type bears a close relationship to the characteristics of the local vegetation. The local vegetation furnishes building material for a people who have not

[21] Carl Peters, *The El Dorado of the Ancients*, p. 192.
[22] P. M. Salviac, *Les Galla*, p. 235.
[23] J. Greenwood, *op. cit.*, p. 403
[24] F. Ratzel, *The History of Mankind*, Vol. 2, p. 271
[25] S. S. Dornan, *Pygmies and Bushmen of the Kalahari*, p. 48.

multiplied their means of transportation for what may be called the baser commodities. Thus, the map (Fig. 1) showing types of vegetation suggests the distribution of house types in general, although there may be discrepancies, especially along the margins of areas, or where recent European settlements have disrupted the former smooth flow of African life. Modifications of the major house types, the result of local tribal and cultural differences there are, but in general the four types of house, the beehive and the cylinder of reeds and grass, the oblong hut of wood, and the crude wattle hut, are the only ones to be found, and each occurs, for the most part, in a well-defined area marked out by the prevailing natural vegetation.

University of Michigan

ANCIENT POTTERY REMAINS IN THE SAGINAW DISTRICT, MICHIGAN

FRED DUSTIN

IT MAY be said in general that the pottery of the Saginaw District is of a somewhat crude type as to quality, form and material, but in the matter of ornamentation, we are at once struck by the infinite variety of design and pattern, and wonder at the ingenuity of the primitive workman and artist.

The culture of a people is indicated by the utensils and implements made by them, so that the various shades, from the most refined civilization to the rudest savagery, are depicted to a great extent, in the ceramic wares fashioned by their hands. Be it remembered, however, that this must not be taken as a sole guide, but should be considered in connection with all the other arts and practices of the various nations and stocks, and we may state that this is especially true of primitive peoples.

The Indians of the Saginaw District were of a medium culture, and we find that they practiced all the rude arts of their neighbors, and owing to their environment, were especially proficient in some and lacking in others. In the matter of transportation, their canoes were models of perfection; in regard to dwellings, their wigwams were miserable constructions, while in the ceramic art we find them fairly proficient. It would be interesting to discuss the reasons for these conditions, but in this paper we must confine ourselves largely to description and comment, leaving the philosophical questions to a possible future paper.

There is not an aboriginal village site in Saginaw County that will not yield fragments of pottery. When I use the term "village site" it must be understood as referring to permanent dwelling places and not to the casual camping site which was temporarily occupied, and which is distinguished by its lack of pottery remains,

although it yields the weapons of the hunter and animal remains in plenty.

These fragments are turned up by the plow year after year, and lie unnoted by the husbandman, although he often stops to pick up the casual arrow-point, or pauses to note a bed of fire-crackled stones that marks the site of an ancient wigwam. It is, therefore, the collector, who, with the keen eye of interest and experience, makes available the hidden information concealed in these seemingly uninteresting potsherds, and again remodels the bowl, the urn or the kettle, and places them before us as most interesting relics of men and women who have gone before us, and whose dust mingles with the dust of their own rude utensils.

From some half-hundred village sites I have gathered pieces of pottery, but in no case have I found a perfect vessel or even the entire pieces of one. In fact, I know of but one complete article of this class, a small urn in the possession of Mr. Henry Bornhoff of Saginaw, which was dug up in Saginaw County within the last three years. It is about six inches in diameter in its greatest dimension, and is a fair specimen. The great Andross mortuary urn figured and described by Harlan I. Smith is only a fragment, having been badly broken, and not all the pieces have been recovered. Mr. Smith in describing it says: "While a pioneer was ploughing on the site, the foot of one of his oxen suddenly sank into a hole. On investigation, the farmer found that the ox had broken through the bottom of an urn which had been turned mouth downward over the head of a human skeleton. This urn is three feet nine inches in circumference and one foot eight inches in height, but before it was broken it must have been at least two feet high."

This huge vessel was found in the Andross Mound which was located in the village of Bridgeport and close to the Saginaw and Flint Interurban Railroad, and just east of the Pere Marquette Railroad. On April 24, 1912, I examined this mound. The knoll had been excavated to the depth of nine or ten feet leaving a nearly perpendicular bank of the yellow "core sand" used in moulding. Near the highest point and some fifteen inches below the surface, a piece of pottery protruded slightly. I dug under it carefully, and was surprised to find that it was nearly fifteen inches

wide and from twenty to twenty-four inches long. The sand in which it was embedded was very soft and wet from the spring rains, and the piece was so fragile that it was possible to remove it in fragments only, filling two cigar boxes of ordinary size. I noted that it was much cracked before I had disturbed it, tiny rootlets having grown between the pieces. It at once occurred to me that perhaps this was a missing portion of the Andross urn, but a later study shows conclusively that it was a different vessel, for the Andross urn was distinctly marked about the middle of its long dimension with cord impressions, and its rim with incised or punched patterns, while the one found by the writer bore on its whole outer surface the impression of a woven fabric. I presume it was a part of a mortuary urn, although not accompanied by skeletal remains, and it was lying on its side, rounding side down.

This urn did not appear to be nearly so substantial in its construction as those smaller vessels that were so evidently used in cooking, and are of comparatively small size. Most of the specimens I have measured are six and nine inches in diameter across the top. By selecting a good fragment it is quite easy to measure the arc of the circle it represents and thus arrive at the true diameter of the top, but to measure the diameter of the swell of the bowl is a difficult matter.

Nearly all of my collection shows that the circular figure predominated, there being but a very few specimens indicating an angular top. In fact, we may say that practically all are of the distinctive Algonquian type, and this also applies to the decorations, for I do not now remember more than half a dozen out of the perhaps thousand pieces in my collection that indicate another type of culture.

The writer's collection numbers about four hundred or more pieces from the tops of vessels, representing about that number of pots, urns or other receptacles. It is safe to say that no two of these, except those from the same vessel, are alike, for nearly all are ornamented and the variety of decoration is as individualistic as was the black-haired artist who formed it.

In the museum room of the Butman-Fish Library the writer has on exhibit a case of pottery including the great fragment from

the Andross Mound, about two hundred fragments from the tops of vessels, as well as other characteristic pottery remains showing delicacy of ornament and beauty of design, also the materials from which it was manufactured. In another case are shown pipes, both perfect or damaged, as well as broken portions such as stems and bowls. There is also to be seen in this case a portion of a pottery tube or cylinder of problematic use, for it does not seem to be a part of a tubular pipe, a specimen of which is occasionally found.

One broken pipe-bowl has a kind of geometrical embellishment upon it that is like delicate tracery, while a fine perfect "mound pipe," which I removed from a grave along with a skeleton, is entirely without ornament. Other pipe-bowls show an average amount and grade of decoration.

To come now to materials and manufacture, all the pottery-ware proper (omitting pipes) appears to have been made by mixing in suitable proportions clay and some tempering material, which as far as my observation goes, was made by pulverizing a disintegrating rock composed largely of feldspar. I have collected several specimens of this stone and have sometimes thought that a part of it, at least, was prepared for reduction by heat. Other pieces merely show the gradual breaking down incident to weathering. Our Indian artisan was well aware that some clay was not suitable, for under heat it would crumble if it contained lime. He also knew that even the right kind of clay untempered cracked in burning. We can imagine that it took many long generations for these essential facts to become fully known, but the pottery before us shows that the makers had well learned the lesson, although they never arrived at the glazed stage of manufacture.

A fresh pottery fracture usually shows a brown-gray color, but sometimes is a brick-red tinge, indicating a percentage of iron, and under a glass of moderate magnifying power, the tempering material seems to form nearly one half of the substance. Some pieces appear to have been given a thin coat of clay of different color from the body of the vessel, thus forming an ornamental surface, usually a fairly bright red, while after use, most of the fragments show blackening from the effects of fire.

Most of the articles appear to have been built up in much the

same manner as the modern potter shapes round objects, for, although the use of the potter's wheel was unknown, the principle was easily followed and two or three simple implements were all that were necessary to the primitive potter. The inside of the object was smoothed by the hand, and it is not so rare to find a slight impression of thumb or finger. It would seem that the larger urns presented some difficulties, for occasionally we note that around the swell of the bowl appear the marks of many cord impressions or those of fine strands of bark, which may indicate that the vessel began to sink down of its own weight or that such a sinking was anticipated and prevented by a judicious wrapping at the right point. Not infrequently we see that a whole vessel bears the impression on its outer surface of woven fabric, probably a light basket which was lined inside with a proper mixture of clay and tempering, and which, after the preparatory drying, was either peeled off or burnt off in the baking process. Some of the fragments in my collection would indicate the latter alternative, for charred substance is seen in the moulded impressions that under the glass appear to have been vegetable fiber.

A most interesting subject is the ornamenting of this primitive pottery; I have tried to show that figures or impressions on the body of the vessel may be merely utilitarian, and incidental to manufacture. As a rule the decoration is on or near the upper part of the object, that is, the rim. Here we find our pottery-maker exercising her art, and I have been much impressed by the variety of the designs. There does not appear to be any of that symbolism which is so strikingly shown by the Pueblo tribes of the Southwest; no pictorial art; no striking geometrical figures, but a ready and skilful use of the means at hand and best adapted to the crude material upon which it is placed.

We find, therefore, cord impressions, small indentations either in groups or running around the vessel, other impressions which look as if made by a small wheel with a notched edge, round recesses made by punching the surface with a properly formed tool, diagonal or perpendicular bars made either with a pointed tool or by impressing a bit of twig or bone into the plastic surface and not infrequently we find that the upper edge of the rim bears impres-

sions of like character. The rim is often rounded and made heavier, thus strengthened, and will sometimes bear ornamental figures on the inner side.

The form of these vessels showed not only ingenuity in manufacture but a keen appreciation of the most desirable shapes and dimensions. We find them of globular form, bottoms rounded and tops drawn toward the center, and we also note that the bottoms were thick, the material tapering from one half to five eighths of an inch at the center of the bottom, to about one fourth to three eighths of an inch near the top of the rim. They presented no angles where contact with other articles was likely; they were rounded on the bottom the better to set them upon three or four stones in the fireplace; also, to present as large a surface to the heat as possible; they were thick at the bottom for strength to resist fire and contact with supports; they were drawn in at the top to avoid as far as possible the spilling of their contents, which also applies to the bulbous form. A measurement of many pieces indicates that nine inches approximate diameter across the rim was a favorite size and undoubtedly was to this extent partially standardized.

I have mentioned pottery pipes and objects other than those used for culinary purposes. As far as my observation goes, the tempering material for these articles appears to have been a coarse sand, the pounded rock being unsuitable on account of the size of the grains which interfered with making the hole through the stem.

Some of these pipes were of neat design and good proportions while others were more crude. The stems were usually lozenge-shaped or oval in cross-section and were short and tapering sharply from mouthpiece to bowl.

It remains to describe some of the more notable village sites where pottery remains are especially plentiful. On the archaeological map of Saginaw County which the writer prepared a few years ago for Dr. W. B. Hinsdale (of the University of Michigan) will be noted village and camp sites, cemeteries, mounds, trails, fords, caches and other data, and references in this paper can be looked up accordingly.

At the center of Section 2, Township 11 North, Range 4 East,

the Tittabawassee and Shiawassee rivers unite to form the Saginaw. The extreme south end of the city of Saginaw embraces a little more than the north half of the section, the city line coming to the point where the rivers unite. Green Point proper is outside the city, but common usage makes that portion of the section lying north of the Tittabawassee and west of the Saginaw known to the general public as "Green Point." A little west of the section-line between Sections 2 and 3, and about five hundred feet from the Tittabawassee River are two large mounds — at least they were large before being levelled by plow and flood — known as the Green Point Mounds, and surrounding these mounds and extending up and down the river were perhaps the most extensive village remains in the County.

This interesting locality has been a favorite collecting ground for the writer, and a large proportion of his best pottery specimens has been collected here.

Since the land was cleared up some thirty years ago or more, it has been under the plow nearly every season, and the occasional spring floods, which come high enough to flood these flats, rush across certain portions in swift currents which sweep the loosened soil away and have disclosed hundreds of relics, among them the pottery fragments.

There is a spot a few hundred feet southeast of the mounds, another immediately west and adjoining the westerly mound, and still another a hundred rods or more west and northwest where, under favorable conditions, I presume a half-bushel of potsherds might be collected. Unfortunately, the owner of the land has become possessed with the idea that the traditional "pot of silver" is somewhere hidden on his three hundred acres, and no longer permits collecting, and the tractor, plow and harrow are doing their work in pulverizing the remains of aboriginal culture.

In the Northwest Quarter of Section 31, Township 12 North, Range 4 East, is another notable locality quite different in character and aspect from Green Point. From the archaeological standpoint, it is known as the Frazer Village Site and Frazer Mound. It is a sand bluff some twenty feet above the ordinary stage of the Tittabawassee River, which was the scene of a fierce and sangui-

nary traditional battle between the Sauks and invading Chippewas and Ottowas, and there is plenty of evidence corroborating the tradition. The light sand after working has often been wind-blown, and I have found this beautiful spot overlooking the river at a wide bend in its course a fine collecting ground for all kinds of Indian remains. Owing to the dryness of the place, the potsherds are not so liable to destruction from cultivation as at Green Point, and I have collected perhaps two thirds or more of the rim of a vessel, picking up the pieces at odd times running over a period of five or six years. They had been scattered by the plow, but from time to time were exposed. I had hoped to secure the entire rim and reconstruct it, but owing to the run-out condition of the land it has not been worked for several years and is too weedy to reward any search, although a few hundred feet southeast I have made some fair collections in an old orchard. These two sites are typical, and while the writer has collected many potsherds at other points, the bulk of his collection has been made at these places, and many fine articles besides pottery have enriched his accumulations.

On the other hand, while localities like the Satchell Village Site in Section 30, Township 11, Range 6 East (Frankenmuth Tp.), the Stroebel Village Site in Section 5, Township 11 North, Range 4 East (James Tp.), are prolific in weapons, utensils, ornaments, and other objects, pottery remains are not plentiful although by no means absent. I have collected potsherds in at least eight townships in Saginaw County as well as in the city of Saginaw and miscellaneous relics in two or three more townships. There were probably at least a hundred permanent Indian villages, large and small, in Saginaw County when the Revolutionary War occurred, and it is not improbable that as many existed in 1800. This implies a large aboriginal population, but it must not be understood that these Indian villages were populous in the same sense that our present communities are populous, for the natural resources of a hunting and fishing people whose food was largely flesh supplemented by a little corn, wild rice, berries and nuts, would not support more than a few hundred persons in a county even as productive as Saginaw.

I have collected potsherds from forty-five or fifty of these villages, and have often pictured to myself the method of manufacture and the scenes attending its production. In the National Museum at Washington there may be seen a number of life-sized groups of Indian men and women engaged in the simple arts and industries of the aboriginal period.

I have not had the privilege of seeing these life-like representations, but have studied them on the printed page, and many times I have conjured up in my mental storehouse of day dreams, not waxen figures but living men and women, black-haired, dark of skin, and with eyes of jetty depths, weaving their baskets, grinding their corn, building the birch-bark canoe or painfully and slowly hollowing the dug-out, chipping the arrow-point, pecking the stone axe and among them, the patient Indian woman forming her water-jar or kettle from the plastic clay.

Perhaps as she works, her baby in its quaint nest swings from a bough before her and other brown children are in cautious play, for danger is always nigh. We see her beating the crumbling rock for tempering and kneading the clay to its proper consistency. We see her mixing the two and soon an urn begins to take shape. How deftly she manipulates it, smoothing inside and out as the work progresses. She moulds the rim, pinching and smoothing it into the desired angle and height. It is now completed as a purely utilitarian product, but we note that it does not satisfy her, and as we watch, she impresses a cord around the top leaving its figure in the clay: also produces a sharp-pointed bit of bone and makes incised diagonal marks around the rim, or perhaps with another implement she impresses different figures or with a short piece of twisted cord indents a series of casts in regular order.

At last the work is finished, and is carefully set aside to season. Tomorrow it will be baked and thus enter upon its usefulness. There is one thing that has especially impressed us and that is the individuality of the potter. The form of the vessel may be conventional, but it is the convention of service and use. It is the artistry of ornamentation that strikes us, each potter impressing herself, as it were, on her product.

Saginaw, Michigan

DISTRIBUTION OF SITES VISITED BY THE UNIVERSITY OF MICHIGAN PHILIPPINE EXPEDITION 1922–1925

CARL E. GUTHE

THE University of Michigan Philippine Expedition of 1922–25 was sent to the Philippine Islands for the definite purpose of gathering additional data upon the commercial relations between the Filipinos and the Asiatic civilizations by means of a study of the furniture occurring with the various types of burials in the archipelago. The Honorable Dean C. Worcester, an alumnus of the University of Michigan, who was intimately connected with the Islands, was directly responsible for this expedition. In the course of his travels about the archipelago he became interested in the occurrence of specimens of Asiatic ceramics in various localities, with the result that, in the course of a trip to the United States, plans for the trip were formulated. Through his hospitality and coöperation, the expedition was afforded very comfortable living and laboratory facilities near the city of Cebu, and independent means of transportation through the use of his yacht, which he placed at its disposal.

The original intention was to make a reconnaissance of the entire coast line of the archipelago, but it soon became evident that practical problems would prevent the consummation of this plan. The area was, therefore, arbitrarily divided into halves on the thirteenth meridian. The expedition confined its activities to the southern half, which includes practically all the Visayan group, the island of Mindanao, and the Sulu Archipelago. Twenty trips were taken to various parts of this area, in the course of which material was secured from at least one locality in each of nineteen of the twenty-two provinces into which the southern

Philippines is politically divided. Obviously it was quite impossible, in the short time of two years, to make an intensive study of all the special regions of this area. An attempt was made to secure an adequate knowledge of the physical features of the entire region and to obtain representative data and specimens from the better known sites in each locality. In addition to the reconnaissance trips of the Director, a more intensive study was made of four small regions within the area by means of agents trained for the purpose. Through the kindness of Mr. Worcester's son, the expedition obtained, through a Moro agent, a large collection from the island of Jolo in the Sulu Archipelago. Mr. Harry Brown, for many years a resident on the island of Siquijor, was of great assistance in securing data and information on the sites occurring in that small island. Juan Abella, a Filipino who had worked with Mr. Worcester on this problem before the expedition arrived in the Islands, acted as agent on the island of Cebu, and secured a large amount of material therefrom for the collections. On the neighboring island of Bohol, intensive work was done through three agents. Owing to the fact that the first of these was found to be untrustworthy, some of the detailed data from this island are probably unreliable. There is no doubt, however, but that all the specimens obtained through him came from somewhere in Bohol.

The physical conditions in which the specimens were encountered led to the grouping of the collections into five classes on the basis of these conditions. Inhumations were encountered either as isolated graves or in large groups, giving rise to the two groups called "graves" and "burial grounds." Because of the fact that all surface indications of these old burials had disappeared, it was rarely possible to secure the usual data on the depth of burial and skeleton position. The native farmers, in the course of tilling their fields, would uncover graves from time to time, saving those materials which interested them. At some later period the expedition's agent, visiting the neighborhood, would hear of the discovery, secure the specimens if possible, and obtain what data the finder was able to remember. Three large burial grounds and several small ones, as well as a number of graves, were dug at first hand, but the great majority of the sites listed under these two

groups in the catalog had been disturbed by native farmers prior to the coming of the expedition's personnel.

Another very favorable locality for finding burials was a cave. A large part of the southern Philippines is of limestone formation, in which a great variety of caves occurs. It was impossible to determine any feature constant to the various caves used for burial purposes. The burials were merely placed on the floor of the cave, or on ledges. In many instances, native coffins had been used, in other localities no evidence of coffins existed. No attempt was made to cover the burial with earth, and there is considerable evidence to show that the vessels placed with the dead were shattered at the time of burial. Subsequent disturbances by the elements, animals, and medicine-men resulted in a confusion of material which utterly prevented any possibility of isolating the furniture of individual burials. In general the caves were likely to yield a larger amount of material than the inhumation sites. Of the five most prolific sites, three are caves and two are burial grounds.

Ceramic deposits were also encountered in localities not associated with burials. For example, there is a gold mine on the island of Masbate which bears evidence of ancient working, and from which a large collection of ceramic specimens was obtained. The sites which yielded ethnological material were grouped with these other sites under the head of "miscellaneous."

Finally, the fifth group of sites consists of those on which the data are incomplete, obscure, or quite impossible. These are all classified under the heading "doubtful."

Table I lists the five hundred and forty-two sites from which material was obtained for the collections of the expedition, on the basis of the five groups described above, and by the provinces of the southern Philippines. The five provinces (Bohol, Cebu, Siquijor, Sulu, and Zamboanga), taken together, show a total of four hundred and sixty-one sites, of which three hundred and eighty-four are those from which the agents obtained material. The accompanying outline map (Map 1) of the southern islands shows the distribution of the sites from which the material was obtained.

This graphic presentation of the localities from which specimens were obtained shows clearly the intensive work on certain districts.

TABLE I

DISTRIBUTION OF SITES BY PROVINCES IN SOUTHERN PHILIPPINES

PROVINCE	Burial Grounds	Caves	Graves	Miscellaneous	Doubtful	Total
Agusan	...	..	...	..	..	...
Antique	...	..	...	..	..	...
Bohol	35	17	55	1	13	121
Bukidnon	...	2	...	..	..	2
Capiz	...	..	...	..	..	...
Cebu	65	17	122	9	2	215
Cotabato	...	..	...	1	1	2
Davao	...	2	...	1	..	3
Iloilo	...	..	2	..	..	2
Lanao	...	..	...	1	..	1
Leyte	...	2	2	..	..	4
Masbate	2	6	1	1	..	10
Mindoro	...	1	...	..	..	1
Misamis	...	..	1	..	..	1
Negros Occidental	...	1	...	..	..	1
Negros Oriental	1	..	3	1	1	6
Siquijor (sub-prov.)	21	13	31	8	6	79
Palawan	...	7	2	..	..	9
Romblon	...	4	...	..	..	4
Samar	3	12	2	..	1	18
Sulu	1	1	3	6	11	22
Surigao	...	7	1	..	..	8
Zamboanga	5	5	6	3	5	24
Luzon	1	2	...	..	..	3
General	...	..	...	3	3	6
Totals	134	99	231	35	43	542

The conditions encountered in other provinces, especially Samar and Leyte, were essentially similar to those met with in Cebu and Siquijor. The assumption is warranted, therefore, that the preponderance of archaeological sites on Cebu, Siquijor, and Bohol is due almost entirely to the methods employed there. It is reasonable to suppose that similar intensive examination of the other Visayan islands would yield similar results. This might prove equally true of the coastal districts of Mindanao. Occasionally

SOUTHERN PHILIPPINES
DISTRIBUTION OF SITES
UNIVERSITY OF MICHIGAN
PHILIPPINE EXPEDITION
1922-25
●- SINGLE SITE
◉- SEVERAL SITES

MAP 1

inquiry brought out no information on sites in certain regions, as, for example, the east coast of Masbate, and parts of the east coast of Mindanao. Time did not permit, however, a more careful examination of these districts, which might have determined how far this lack of sites was actually due to conditions, and how far due to reticence on the part of Filipino informants.

In order to give an adequate idea of the collections obtained from these sites, the contents of twelve of them have been listed in Table II. These twelve sites, which were found in ten provinces, were among the most prolific ones from which material was obtained. A short description of each follows:

I. A series of three caves, within a few yards of one another, on the small island of Dinago, just north of Placer, Surigao, on the northeastern coast of Mindanao. Remains of coffins were seen. The medicine-men had made use of the caves, and rearranged the material found on the surface. A trench two feet deep disclosed the fact that evidence of human deposits did not occur below the surface. These caves were first visited by Mr. Worcester and later by the Director of the expedition.

II. A single cave in a rocky islet connected by a tidal flat with the small island of Suluan, off the southeastern point of Samar. The cave is low and small, with two openings, and is probably washed to some extent by waves in the more violent storms. The Director and his party spent five days in screening the earth within the cave. There was a quantity of skeletal material, of which the more perfect specimens were saved.

III. A single large cave in Sucgang Barrio, seven kilometers east of the town of Loay, Bohol. This cave is directly on the well-built South Road of this island. The Director and a force of local laborers spent four weeks in carefully excavating this cave and the talus which had formed on the outer side of the lower opening. The upper opening acted as an entrance for torrential streams. The deposits were completely dug over, sometimes to a depth of three feet. Evidences of coffins occurred. The deposits had been so intermingled by the elements that no adequate stratification existed.

IV. A burial ground on a hilltop, which was later destroyed

TABLE II

DISTRIBUTION OF MATERIAL IN TWELVE SITES

	Surigao	Samar	Bohol	Cebu	Cebu	Negros	Masbate	Tablas	Coron	Coron	Zamboanga	Jolo
CERAMICS	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Green	11	22	79	6	28	46	4	1	5	1	29	45
Grey	1	1	40	2	3	22	1	3	..	..	8	16
White	..	4	26	1	2	12	2	..	..	..	6	9
Brown	2	...	31	2	..	14	..	..	..	1	7	24
Blue and White	15	43	40	1	..	...	30	17	36	..	78	23
Black and White	3	3	23	4	..	...	2	1	..	..	11	7
Overglaze	..	...	4	..	..	...	3	1	5	..	8	6
Dark Jars	1	11	28	1	..	2	3	9	6	..	45	20
Unglazed-wheeled	1	...	7	2	..	2	..	..	..	..	1	...
Native ware	12	1	19	3	..	13	2	1	6	86	5	...
Miscellaneous and Modern	..	...	...	..	..	2	1	..	..	..	...	10
European	..	...	...	..	..	...	..	..	..	..	2	4
OTHER OBJECTS												
Iron	5	1	2	3	1	2	2	..	1	1	...	1
Copper, brass	3	1	5	..	..	2	1	..	5	..	3	4
Lead	..	1	1	..	..	1	..	..	1	..	1	...
Gold	..	1	4	..	1	4	..	..	..	..	...	...
Glass	..	1	1	..	..	1	..	..	2	2	...	1
Stone	..	...	3	1	1	2	6	..	1	..	1	...
Shell	8	5	13	2	3	3	1	..	6	4	4	...
Beads	5	4	1	3	1	1	..	..	1	..	6	...
Miscellaneous	11	5	4	5	..	1	1	..	4	..	1	...
Skeletal	7	14	11	1	..	3	1	2	4	3	1	...
Totals	85	118	342	37	40	133	60	35	83	98	217	170

by the neighboring cement works. It was located about twenty kilometers southwest of the city of Cebu. The Director and his party spent three days in excavating this site. Thirteen skeletons were found, only a few inches below the surface, buried at length. Most of the specimens obtained were associated with the burials.

V. This site was reported by Juan Abella, the Cebu agent. It was described as a single burial at full length about twenty inches below the surface. It was found in the Barrio Talot, near the town of Carcar, on the southeastern coast of the island of Cebu. Most of the material obtained was associated with the burial, and the rest of it was picked up on the surface near by.

VI. A large burial ground, near the village of Tabon, just south of the town of Vallehermosa, on the eastern coast of the island of Negros. It was excavated by Mr. Worcester and his party before the arrival of the expedition in the islands. Most of the burials were jar burials.

VII. A placer gold mine on the eastern shores of Port Barrera, in the northwestern part of the island of Masbate. The vein of gold ore outcrops on the southern exposure of the hills at this point. The present mine operators have found that the talus below the outcrops contained a quantity of broken ore and many evidences of habitation. The Director and his party spent several days here securing a representative collection of the ceramic material which occurred in this talus deposit.

VIII. A fissure in the limestone cliffs about 150 feet above high-water mark near the northeastern point of the island of Tablas. The deposit had been heavily washed by water coming down the fissure from the top of the cliff. It is estimated that about six burials had been placed in the fissure at various times, causing a deposit of sherds and minor objects in an area five or six feet long and four feet wide, to a depth of about eighteen inches. This site was studied by the Director.

IX. Another fissure, somewhat larger than the last, which was found in the cliffs on the northeastern coast of the small island of Peñon de Coron, in the Calamianes group, just north of Palawan. It had apparently been used as a burial place for some time, and had also been heavily disturbed by water pouring down from the top of the cliff. This site was also excavated by the Director.

X. A cave on the northwestern coast of Peñon de Coron, the same island which contained number IX. It is included here because of the radical difference of its deposits, which consisted almost entirely of highly ornamented and irregularly shaped vessels of

native ware. The cave was large, with a very irregular floor, and the material was found entirely on the surface. This cave was examined by the Director.

XI. A large burial ground on the small island just off the southeastern point of the island of Basilan, south of Zamboanga. It was first visited by Mr. Worcester, and later twice by the Director. At present a village is situated on the site. The collections were obtained by purchase from the villagers who had made them in the course of construction and farming.

XII. This collection was obtained from the island of Jolo, in the Sulu archipelago, through the coöperation of Mr. Fred Worcester. A Moro friend of his, Panglima Sabudin, spent about forty days in the interior of the island making a house-to-house search and running down every story of old Chinese plates which he heard. Later, through other agents, additional material from Jolo was added to this initial collection. All the material was purchased from the agents.

Table II has been compiled from the field catalog. It is divided into two parts, the first of which lists the kinds of ceramic material, and the second the classes of secondary material. The figures given for each site are the total of catalog numbers used for each group of material obtained from that site.

The ceramic material was all sorted in the field and catalogued by vessels, so far as the fragments could be identified. The figures under the ceramic groups, therefore, render a dependable index of the number of vessels found at each site. The grouping of these vessels is based only on objective data. No attempt has been made to differentiate between them on the basis of age, size, shape, or glaze texture. The major part of the specimens are plates and bowls, with small jugs and jars next in abundance. The vases which frequently occur in collections of Chinese ceramics are almost unrepresented. The collections brought back to Ann Arbor contained approximately one thousand unbroken vessels, but the number of fragmentary vessels is far in excess of this. For this reason the figures in the table refer in the main to fragmentary specimens. The definitions below serve to clarify the phrases used for the ceramic groups.

Green: all monochrome vessels which are predominantly green, varying in shades from a light gray green to a dark olive green.

Gray: monochrome vessels which are predominantly gray.

White: all monochrome vessels of a white or cream color and also some gray vessels which are clearly of the same type as certain of the cream-colored ones.

Brown: all monochrome vessels of various shades of brown. A large part of these are small jars and jugs.

Blue and white: all vessels which have a blue design upon a lighter ground under a more or less transparent glaze.

Black and white: all vessels with black design on a lighter ground under a more or less transparent glaze.

Overglaze: all vessels, regardless of other features, which have designs over the glaze. These designs are usually of more than one color.

Dark jars: all jars with a glaze which is usually a dark shade of brown. These are large jars and most of them have dragon designs upon them.

Unglazed-wheeled: these vessels have been thrown on a wheel and are of a gray color. They do not bear any traces of glazing and when decorated have designs incised or stamped upon them.

Native ware: all pottery vessels which are coarse and reddish-brown or black. Many of them bear various incised and stamped designs.

Miscellaneous and modern: those vessels which do not readily come under the classes listed above and those vessels which closely resemble material obtainable today in the stores in the Philippines.

European: this contains all vessels which are obviously European in origin.

The secondary material obtained from the caves consists largely of weapons, ornaments and skeletal material. The catalog numbers frequently contain more than one specimen, as, for example, in the case of unrelated teeth, where several hundreds were placed under one number. Most of the groups of these secondary objects refer to the material of which the specimen is made. All beads, however, regardless of the material, have been grouped under one heading. A large proportion of the brass, glass and shell objects

are bracelets. Under the head "Miscellaneous" occur articles of wood, cloth or paper, and similar substances. The skeletal material includes skulls, long bones and unrelated teeth. Most of the smaller articles were obtained by sifting the earth of the caves and that in the neighborhood of the bones of the inhumations.

The actual distribution of the sites and the objects found in them presents certain interesting features. In the eastern Visayas, that is, Surigao and Samar, the blue-and-white wares occur far more frequently than any other type. In the central Visayas, that is, Cebu and Negros, the monochrome wares, principally those with a green color, predominate. In the north, however, in Masbate, Tablas and the Calamianes, the blue-and-white is again the predominant type of ware. In the Moro provinces in the south, that is, Zamboanga and Sulu, the large jars are more common than elsewhere, but the blue-and-white wares are still the dominating feature.

The conclusions which may be drawn from these data are numerous. The most obvious is, that, if it were possible to study the other districts in the southern Philippines as intensively as those regions in which the agents worked, it is entirely probable that a similar number of sites and a similar quantity of material would be obtained. Another conclusion is that while there is a general uniformity in the material obtainable from the burial places of the coastal peoples of the southern islands, yet the variety is such that it offers a number of detailed subjects for intensive research. Owing to the fact that practically all the intrusive Asiatic objects are of secondary artistic value, many ceramic problems can be more readily studied in these commercial fragmentary pieces than in the more perfect art specimens. Again, a very superficial examination of the specimens themselves brings out the fact that they were brought together in the Philippines from a large number of different localities which probably range from Singapore and Java on the south to Japan and Korea on the north. Because of the conditions under which the material was secured, it was impossible to obtain any information regarding relative age from stratification. This means that the identification of the wares and smaller objects must be done entirely on stylistic criteria.

University of Michigan

INDIAN MOUNDS, WEST TWIN LAKE, MONTMORENCY COUNTY, MICHIGAN

WILBERT B. HINSDALE

IN ALBERT TOWNSHIP, the southwest corner of Montmorency County, occupying nearly the whole of Section 29, there is a beautiful clear-water lake, called West Twin Lake. East and West Twin Lakes are separated by a strip of low land less than a quarter of a mile in width. There are said to be a few Indian mounds at different places near the east lake, but the informants were very indefinite in their descriptions and locations.

Upon the north shore of the west lake there are probably fifteen mounds, although this description appertains definitely to a group of eight, about the center, east and west, of the north bank (see Fig. 2). They are upon the SW. ¼ of the SE. ¼ of Section 20, land owned by Mr. Herman Lunden of Gaylord. The distance from the mounds, which are situated upon a level plain 30 feet above the lake at this point, to the crest of a gravelly declivity, which pitches abruptly down to the water, is 20 feet to the nearest and 80 feet to the farthest. From the first, or east mound, to the most westerly of the group the distance is 460 feet. The soil is gravelly sand. The plain upon which the mounds are situated is an open space overgrown with grasses, low shrubs and scattering jack pines. Formerly this territory was a heavily wooded pine forest.

Running along the bank of the lake, past the mounds, is a well-worn path now being trodden by fishermen and cows. Not many years ago it was followed by lumbermen. According to the statement of an old woodsman, who has lived in the vicinity from a time before the surrounding lands were lumbered, this path was as distinct as at present. It is, no doubt, the old trail of the Indians who walked the shore long ago, coming to visit the monuments

of their dead and going from village to village. (See Pl. XIV, Fig.1.)

Upon the fourth day of June, 1927, accompanied by Professor C. W. Angell of the University Museum staff, the writer visited

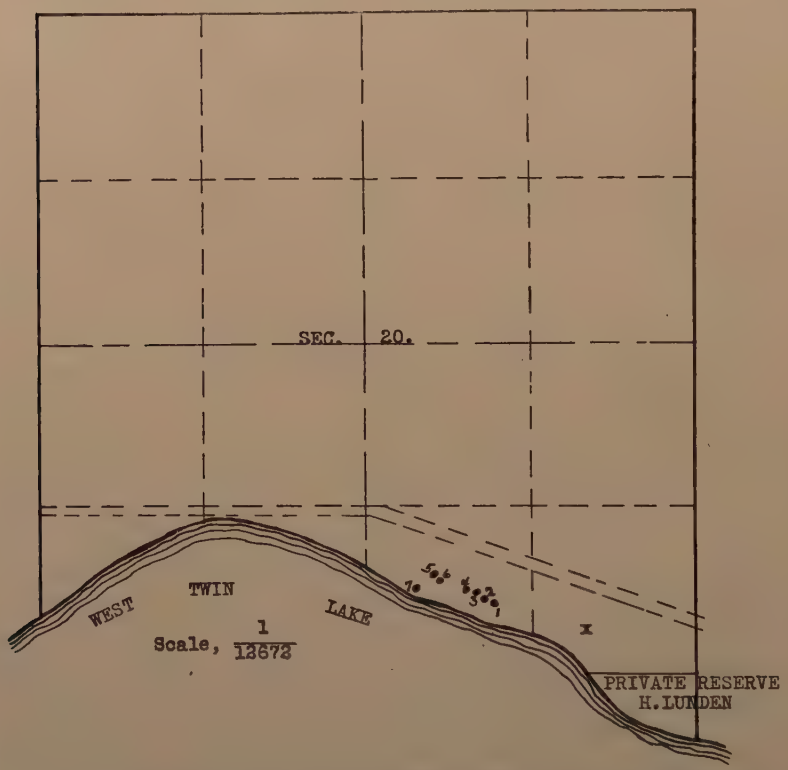

Fig. 2. Chart showing the location of seven Indian mounds on the property of Mr. Herman Lunden on the north shore of West Twin Lake, Montmorency County, Albert Township, Section 20. See table at top of p. 93.

the location being described and began excavating Mound 2 at once. Four days were spent in digging, two to five men being employed at different times. Each mound will be described later in detail. The following table indicates the dimensions and relative situation of the mounds.

TABLE SHOWING SIZE AND POSITION OF MOUNDS

Mounds	Diameter in feet	Height in inches	Distance from "X"	Distance south of line * to center	Distance to lake
1	28	40	730	18	50
2	25	34	770	13	55
3	20	30	810	20	70
4	14	15	900	36	70
5	11	14	1190	50	80
6	8	13	1180	80	40
7	5	8	1185	100	20

* Line running N. 65° 15′ west from "X" in lower right-hand corner of the diagram.

While there are no data indicating which mound was built first, or whether they were all commenced at the same time, there was proof that the interments, above those deepest in the earth, were made at different times and that the soil was mounded up as later burials were made. In two or three mounds there had been three different times of burial; the first 2½ to 3 feet below the ground level, the second upon or a little above the ground level and above this second burial others but 12 inches from the top. One of the mounds contained six skeletons; all those examined, except a very small and low one, contained no less than three. Layers of two colors of sand and wide strata of charcoal and ashes were in every case found on top of the two lowest interments. The soil all through the mounds was interspersed with "fire stones," that is, stones that had been heated and cracked by contact with hot fires. Evidently earth had been placed upon the bodies to the thickness of several inches, and fires burned on top of this covering.

In some of the mounds, especially No. 6, the bodies had been deposited and "laid out" with great care. In others, bodies or bones had been "dumped" without any arrangement. A great many of the bones in the second stratum were evidently stripped of their flesh before being covered; sometimes the skeletons had been entombed entire and no doubt "in the flesh." The mixed-up

bones indicated perhaps a communal burial. Such deposits are called ossuaries. While in half of the mounds there were evidences of fires having been kept burning for a long time, or at very numerous intervals, the thick layer of earth above the bodies had prevented any contact of the bones with heat; that is to say, there had been no cremation. It was the custom of many of the Algonquian tribes about the Great Lakes to keep fires burning for four days upon burial places.

Twenty-three skeletons, in whole or in part, were exhumed; very old persons, persons in full vigor, bones of men, women and children and one dog were taken from the six mounds excavated. Some of the lower jaws had lost all their teeth, others had full complements of perfectly sound teeth. Evidence of dental caries was frequent. In the jaws of the children the "second set" of teeth were in the stage of partial development below the primaries. Many of the bones crumbled at the slightest touch. Some had already become "mingled with the dust" except a few spiculae. Two or three skeletons were in excellent preservation. Those buried the deepest were the best preserved.

A peculiarity of the material in and of the mounds was the entire absence of any kind of artifact, except a few small perforated salt water shells and some knotted string in Mound 6 in which the skeletons of a woman, a child and a dog were found in immediate proximity. There was not so much as a flint flake or a hammer-stone discovered either in the earth shoveled and troweled over or upon the surface of the field. Probably, however, if the land upon which the mounds stand should be plowed, workshops and village sites would be found.

Mounds 1 and 2 (see Fig. 3) were the largest and were contiguous. It could be plainly discerned that the most of the earth entering into their construction was taken from neighboring depressions or wide pits. The others were surrounded by shallow but distinct trenches or moats from which the earth was taken mostly for making the bodies of the mounds. Pockets of very light-colored sand were interspersed with the "golden" sand that formed the main body of the works. This silvery sand, upon comparison with the sands of the lake, is conjectured to have been brought up the lake

bank from the lake bottom. As stated, there were black bands through the mounds, of ashes, charcoal and fire stones, sometimes to the thickness of a foot.

The first question asked by the ordinary individual when constructions such as those being described are considered, is: "How old are they?" or, "When were the mounds made?" No one knows, although it is possible to approximate a time since which

FIG. 3. Mounds 1 and 2

they were not made. Stumps of pine trees were upon the mounds. The annular rings indicate the growth of a hundred and fifty years; the trees which stood upon the stumps were cut forty years ago. The burials were made according to this computation at least two hundred years ago. If one could determine the rate of osseous degeneration or disintegration in soil of the character and situation of the mounds, he could be more definite, but chemists have no method of making such determination.

Several theories will account for the extensive fires that were kept up or frequently kindled over the lower parts of the mounds

or where the mounds were later rounded up. One is that domestic activities were carried on there. Sometimes bodies were buried under the dwelling and the place continued as a habitation. Again, as soon as a death occurred in the house, it was immediately destroyed and a domicile established elsewhere. For a statement of the behavior of Chippewas after a death, see *Kitchi-Gami* by J. G. Kohl, p. 106: "The lodge was immediately destroyed and dwellers sought refuge elsewhere after a death." It is also possible that some bodies were buried in the wigwam and that it was then set on fire. That would account for the wide ash and charcoal distribution across the entire base of the mound. If the fires were for cooking food, it would appear that there should occur such objects as pottery fragments and used and abandoned utensils. The little piles or circles of fire stones among the charcoal and ashes, would indicate, on the contrary, some purpose aside from mere bonfires.

It was the custom of some of the historic Indians to dispose temporarily of the bodies of their dead, so that the flesh would decay or be otherwise removed and the larger bones, at a later time, gathered and permanently buried. Mr. Bela Hubbard, *Memorials of a Half-Century*, p. 231, refers to this in his description of "The Great Mound at River Rouge." A village or community would assemble at certain places and hold a common funeral or festival of the dead, accompanied by loud and plaintive expression of sorrow and incantation. Upon such occasions feasting and dancing would continue to the limit of physical endurance. It might be that a kind of pyre was burned over the former burials before the later interments were made and covered up. That some of the fires were covered or smothered while burning is shown by the finding of large pieces of charred wood and bark under and mixed with the sand and gravel of the upper segments of the structure. The height of the mound would be increased by the thickness of the layers of charcoal, ashes and earth left and placed at these times upon the top of the old foundation.

Originally the mounds were much higher than after the winds and storms of many years had swept over them. The wear and tear of heaps of loose, sandy soil by the elements is very considerable.

In many old Indian burial places bones and skeletons have been entirely exposed by the wind alone. I have noted this at Ossineke in Alpena County and at various other places near the shore of Lake Huron above Alpena.

The method of examining the mounds was, except in the case of Mound 2, to begin upon one side at the ground level and remove all the earth as progress was made toward the center. The undisturbed earth stood in a vertical face before the workers. As bones were exposed they were carefully dusted off around the edges for photographing and measurements. A trowel, a sharp-pointed stick, brushes and, in the absence of a sieve, a comb were used after the shovels were laid aside. A common "coarse comb" is an excellent tool for the raking over of earth supposed to contain small objects. After the mounds, except a narrow rim of the outside, were shoveled away, wide trenches were carefully sunk below the soil level, which in several of the examinations disclosed the most interesting interments.

Very much credit is due to Mr. Lunden, who owns the tract, for bringing to the attention of the Museum staff the existence of this group of well-preserved, undisturbed Indian antiquities which has, so far as the writer is informed, no equal within the state, except the group upon Grand River below the city of Grand Rapids. As soon as the excavations were finished, Mr. Lunden set to work to have the mounds restored to their original shape and to encourage the grasses, shrubs and "second growth," natural to the situation, to renew themselves so that the rains and winds will not do damage. It is Mr. Lunden's intention to have all the mounds upon his properties perfectly restored and reserved as parks.

DESCRIPTIONS OF MOUNDS

MOUND 1

Slightly oblong; longest diameter 28 feet; height 40 inches; distance from lake 50 feet. Large depressions near base, spaces from which earth was probably taken for construction. Depression in top of mound indicating that some time has elapsed since it had been "dug." This mound really touches Mound 2 upon west side of its base. Mounds 1 and 2 at base form a kind

of figure 8 upon the ground surface. Was not excavated. See Fig. 3 and Plate XII, Fig. 1.

(A second examination of Mound 1 was made in August, 1928. A deposit of unusual artifacts was found which will be described and detailed in a subsequent report.)

FIG. 4. Section of Mound 3, showing strata of charcoal, fire, stones and ashes

MOUND 2

Slightly oblong; E. and W. diameter 34 feet; N. and S. 31 feet; height at center 42 inches. Wide shallow holes, as with Mound 2 close by, from which earth was probably taken for its construction. Depression in top, indication that some years since an attempt had been made to examine its contents. Trench 5 feet wide, 4 feet deep was dug through center. Two feet from top was uncovered a mass of bones in good preservation, placed indiscriminately. Lower, beneath a wide mass of charcoal and ashes and a stratum of sand, were found large, long bones and fragments of skulls. One of the lower jaws was entirely devoid of teeth and the rami indicated that the teeth had been lost a long time before death; hence a jaw of an aged person. Masses of charred wood 10 inches long and 2 inches thick were found in the layer of ashes and charcoal. While this mound was "rich" in whole and fragmentary

bones there was not a skeleton or skull intact. The burials had probably been communal, that is, deposits of bones and not of bodies, several persons contributing the osseous remnants of their dead after denudation of the soft parts had taken place. This condition is in striking contrast with that in Mound 5. See Fig. 6.

MOUND 3

Diameter 20 feet; height 30 inches; distance from lake 70 feet. Top of mound covered with humus; below, golden sand and lake wash. At different levels were strata of burned sand, mixed with ashes, charcoal and fire-cracked stones. Within 6 inches of the top there had been an intrusive burial of one person. Bones were in a disarranged emplacement. At a depth of 18 inches, and below the black band of ashes and charcoal, were two disarranged skele-

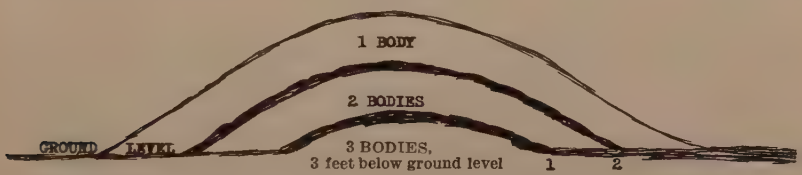

FIG. 5. Diagrammatic section of Mound 3. The lines designated by the numbers 1 and 2 represent strata of charcoal and ashes

tons. Below these was a second black band similar to the one above. Five feet from the top of the mound and 2½ feet below the ground level were two skeletons lying side by side, N. and S. Just under these was a third with the skull towards the east and the body bent so that the legs of the three were all together, feet towards the N. The lower skull was in perfect condition with all the teeth sound and in place. Cross-section of mound shown in Figs. 4–5. See Plate XIII, Fig. 3; Plate XIV, Figs. 2–3.

MOUND 4

Diameter 14 feet; height 15 inches; distance from lake 70 feet. Soil in mound golden sand natural to the location. No evidences of fire or stratification. Twelve inches below the top were the broken skulls and larger bones of three individuals. No deeper burials. See Plate XII, Fig. 2.

MOUND 5

Diameter 11 feet; height 14 inches; distance from lake shore 80 feet. Mound surrounded by ditch 8 inches deep. Sixty inches from top of mound, or 47 inches from ground level, a complete skeleton was disclosed. Figure 6 shows the skeleton before a single bone was removed. All the bones of the body were recovered, even the hyoid. Teeth perfect. Length of skeleton

as lying semiflexed, east and west, 54 inches. There was no evidence of fire in this mound, the mass of it being uniform in color and character.

MOUND 6

Diameter at base 8 feet; height 13 inches; distance from lake 40 feet. Forty inches below the natural level of the ground were partial skeletons of a woman, a child and a dog. Skulls were in condition to be distinctly identified.

FIG. 6. Skeleton, undisturbed, in Mound 5, forty-six inches from ground level, sixty inches from crest of mound

Many parts of body bones were too much disintegrated to permit skeletons to be secured entire. Woman's and child's skulls were touching, bodies lying side by side. Skeleton of dog lying diagonally across both bodies. Skull in close proximity to the child's left shoulder. Numerous cowrie shells embodied in a "hairy" mass of a probably decomposed skin bag and a piece or two of knotted string were under the child's lower jaw. Soil of mound sand, probably taken from surrounding ditch. No evidences of fire around the mound. Bodies lying east and west. Skull of dog illustrated to right in Plate XIII, Fig. 3.

MOUND 7

Diameter 5 feet; height 8 inches. Contained only very few fragments of child's skull and ribs. Rest of skeleton seemed to have disintegrated entirely. No evidences of charcoal or ashes.

FIG. 1. General view of field upon which mounds are situated. Mounds 1 and 2 and West Twin Lake in distance

FIG. 2. Workmen in Mound 4

FIG. 3. Examining Mound 8

FIG. 1. Excavating Mound 8

FIG. 2. Lower jaws of man, woman and child

FIG. 3. Human skulls (Mound 3) and skull of dog (Mound 6)

FIG. 1. Old Indian trail along Lake Bluff passing mounds in distance

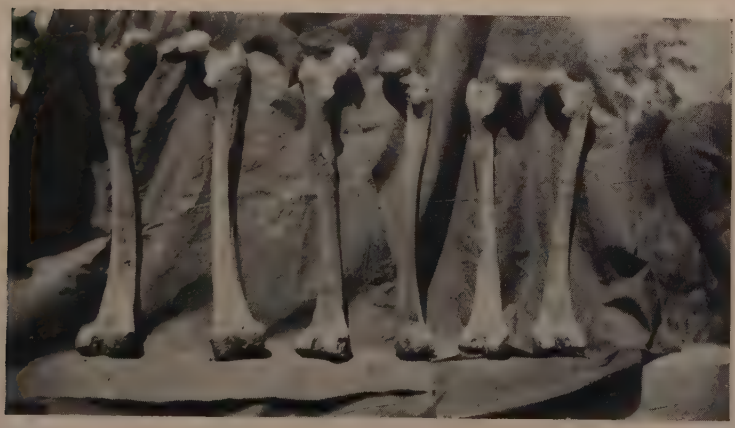

FIG. 2. Three pairs of femurs from Mound 3

FIG. 3. Skulls from Mound 3

MOUND 8

Location not indicated upon map. Surrounded by small clump of poplar trees. Contained thicker layers of charcoal than any other mound of the group. Under a layer of ashes and charcoal, 10 inches thick in one part, three skulls were found close together with a few leg, arm and pelvic bones, all badly disintegrated. Fifty inches from the crest and 24 inches from ground level was another similar deposit and in similar condition. Birch and jack pine bark in 8 inches of black soil was also found at about this depth. Some of the bones appeared to have been somewhat scorched but crumbled upon being examined. See Plate XII, Fig. 3; Plate XIII, Fig. 1.

University of Michigan

THE QUANTITATIVE MEASUREMENT OF SOCIAL ATTITUDES

JOHN W. ALBIG

A SOCIAL attitude may be broadly defined as a tendency to act with reference to some phase of associative life. In the terminology of the social psychologist, attitudes have been designated as "essentially an incompleted or potential adjustment behavior process. It is the set of the organism toward the object or situation to which an adjustment is called for."[1] Professor Allport has called an attitude "the motor set built up by suggestion."[2] Thomas and Znaniecki, in the methodological note introducing their study of the Polish peasant, consider an attitude as a "process of individual consciousness which determines real or possible activity of the individual in the social world."[3] A definition thus broad seems to be coincident with the boundaries of social psychology.

Attitude has sometimes been thought of as a generic term, of which opinion, conviction, belief, prejudice, and the like, were expressions. In fact, early dabbling in quantitative measurement (in the field of attitude measurement, "early" refers to studies from 1915 on) frequently, at least implicitly, used "attitude" and "opinion" interchangeably. Attitude, as defined, is a subjective state, a "motor set," a "set of the organism." As such, neither opinion nor other forms of behavior provide an accurate index of attitude. It is not difficult to think of illustrations in which expressions of opinion represent contradictions of attitude. This has been recognized, and the two terms are now held apart, in theory,

[1] Bernard, L.L., *Social Psychology*, p. 246.
[2] Allport, F. H., *Social Psychology*, p. 244.
[3] Thomas and Znaniecki, *The Polish Peasant in Europe and America*, pp. 1–86.

though not in the practice of what is called attitude measurement. Quantitative attitude measurement is, strictly speaking, attempt at opinion measurement. Professor Read Bain suggested, in a paper which will be found in the *Proceedings of the American Sociological Society*, 1927, that, as opinions are so fallible a guide to attitude, a more accurate index is to be found in the measurement of behavior, other than opinion. That is, measure the way a man votes, for example, not the way he says he will vote. But external pressure may modify forms of overt behavior quite as readily as opinion, so that these represent no surer index to attitude. By no method now existing can any form of attitude be measured as such. Attitudes are subjective states. But opinion can be measured in some degree, and the probability of opinion and attitude coinciding increases as the tests proceed away from any material on which individual or social taboo perverts the truth of the subject.

The measurement of attitudes proceeds through two channels. The first is the study of behavior and experiences, translated into terms of the attitudes which have motivated them; and the second, an attempt at quantitative measurement of attitude through some form of direct ascertainment of tendency to act. The circuitous route may, in the end, provide the more accurate information.

The social case history, the life-history with its rapidly bettered technique, provides a type of methodology used in the study of behavior. These may follow a rather definite outline as in the early case studies of delinquency by Healy,[4] or the more recent contribution of Miss Van Waters.[5] Or, as in the life-history of an immigrant in Thomas and Znaniecki's study of the Polish peasant, a rambling autobiographical form of life-history may be introduced. Autobiography, in general, has been frequently used by the sociologist, political scientist, and historian in determining attitudes of leaders of an era. The extension of the case history to small institutions has been presented by Professor Cooley in a paper read before

[4] Healy, Wm., *The Individual Delinquent, and Mental Conflicts and Misconduct.*

[5] Van Waters, Miriam, *Youth in Conflict.*

the American Sociological Society in 1927. The use of letters as an indirect method of determining attitudes has been utilized in the noteworthy contribution to methodology in the study of the Polish peasant. The use of poetry as a source of sociological material has recently been suggested by Professor Read Bain.[6]

All the arts have, at times, been referred to as sources of material which may be translated into attitude. Professor Odum's recent collection of Negro songs provides material for such study.[7] In a very broad sense, the anthropologist continually translates culture forms into the social attitudes which have motivated their creation. A collection of source materials, such as Frazer's *Golden Bough,* becomes meaningful when discussed in terms of the social attitudes which have motivated them. A collection of 5,000 Kentucky superstitions provides a series of puzzles as to the attitudes which created them.

If, on the other hand, not the attitudes, as facts, or the behavior resulting from the attitude, but the cause of any attitude, be the subject of investigation, then, indeed, the search would probably range from the glands regulating personality to the effects of climatic conditions on character traits, from physiology to environmental influences.[8] The causes of any attitude would be a complex organic relationship.

The attempt at quantitative measurement of attitudes has been made in recent years in all the social sciences. As stated earlier, this has been in reality an attempt at quantitative measurement of opinion. It is the purpose of this paper to present briefly some examples of typical methodology in measurement. This problem breaks into two parts: first, the principles and technique of the construction and the use of forms of opinion tests; and, second, the statistical methodology of utilizing the materials collected This paper is limited to the first, the principles of method underlying the tests. The discussion of the statistical technique of utilizing

[6] Bain, Read, *Sociology and Social Research,* Vol. 16, No. 1.

[7] Odum, W. H., and Johnson, G. B., *Negro Workaday Songs.*

[8] Dexter, E. G., *Conduct and the Weather, Weather Influences;* Berman, L., *Glands Regulating Personality.*

this material will be found in contributions by Allport and Hartman,[9] Sturges[10] and Thurstone.[11] An analysis of the literature of the measurement of opinion shows what seems to me to be six major variations in principle of construction of opinion tests.

The order of merit method is a simple type of measurement which the psychologist constantly uses. It has frequently been used in tests of judgment of weights, measures, sizes, colors and the like. The materials of the test vary with the subject under consideration, but the principle is that of arrangement of units into scaled order by the person tested. A study in statistical ethics, largely based upon this principle, is being carried on by Professor Brogan at the University of Texas.[12] After a series of questionnaires, in which students were asked to list the most reprehensible practices they knew of, he selected the sixteen which were most frequently mentioned. These are presented to class after class, for ranking according to order of merit (or, I suppose, in this case, demerit). Professor Brogan's results are interesting. He finds that the coefficient of correlation is plus 0.98 in rating the various practices. Professor Donald Young reports an attempt to measure social distance by having students list twenty-five nationalities in order of their "social distance" from the student.[13] Achilles uses an order of merit method in one section of his study of the effectiveness of social hygiene literature.[14] One of the more obvious criticisms of the order of merit method, as used by Brogan and by Young, would seem to be the increase in inaccuracy toward the end

[9] Allport, F. H., and Hartman, D. A., "The Measurement and Motivation of Atypical Opinion in a Certain Group," *Am. Pol. Sci. Rev.*, 19 (1925) : 735–769.

[10] Sturges, H. A., "The Theory of Correlation Applied in Studies of Changing Attitudes," *Am. Journ. Soc.*, 33 : 269.

[11] Thurstone, L. L., "Attitudes Can Be Measured," *Am. Journ. Soc.*, 33 : 529–554. "The Measurement of Opinion," *Journ. Abn. and Soc. Psy.*, 22 : 415–430.

[12] Brogan, A. P., "Problems and Methods in Statistical Ethics," *Publ. Am. Soc. Soc.*, 21 : 174–177.

[13] Young, D., *Journ. Abn. and Soc. Psy.*, 22 : 235–242.

[14] Achilles, Paul, *Effectiveness of Certain Social Hygiene Literature.* Columbia Ph.D. thesis.

of such a list. If a student is asked to list twenty unethical practices, or to enumerate twenty-five national groups in the order of their social distance from the subject, is there not the probability that the first named will be the most obnoxious practices or nationalities, that those toward the middle of the list will be the least obnoxious, and that the ones at the end will represent practices or nationalities which he utilizes merely to fill in the requisite number? If the number involved be indefinite, it would seem that there would be a greater probability of more accurate statement of opinion of the student. Then those which most frequently appeared in the larger number of lists could be correlated. However, the order of merit method, it would seem, can be of but very little use in the measurement of opinion. Used in a psychological test of comparative size or weight of units, and the like, the units are at least present to each subject. In the classification of opinions, the units are not all necessarily of significance to each subject. He may have no opinion of a Korean, let us say, or of some unethical practice. Therefore, to place twenty national units, or twenty ethical units, before a subject who has an opinion on perhaps fifteen; and then to draw up a scale on the basis of the original number, is to bring in a very large element of statistical inaccuracy in the calculation of results. The test is not analogous to that of placing twenty physical units before the subject for discrimination.

The simple questionnaire, in which a "yes" or "no" answer to a series of statements is desired, has enjoyed a wide usage in opinion measurement. It is needless to state that this method has been used with laborious futility when the questions have been direct requests to produce a subjective state, so that the examiner might glance at it. To ask a man whether he is progressive or conservative or radical in any attitude, is to put a question which he would probably be unable to answer, even if he were willing. This, to be sure, is only one of numerous criticisms which might be presented on such a questionnaire, criticisms arising because of unknown, changing, and suggested factors. Yet it must not be assumed that recent periodical literature is devoid of reports based on such contrivances. The sentence questionnaire serves as the basis

for studies reported during the last five years by Shuttleworth, on money-mindedness;[15] by Meier, on general opinion;[16] by Case, on religious knowledge;[17] by Achilles, on opinions based upon certain social hygiene literature;[18] by Symonds, on a general social attitudes questionnaire;[19] by Bain, on a study of religious knowledge and opinion among college students;[20] and by Ream, with a general social relations test.[21] I refer here to questionnaires composed of series of sentence statements to be answered by an unqualified "yes" or "no." While the simple questionnaire may serve a useful purpose at times in recording factual information, it has certainly proved to be much too crude an implement for the recording of opinion. It appears to me that there are three principal objections. First, in almost all matters of opinion, a variation of two points, "yes" or "no," represents so limited a response among the possible opinions that it is highly inaccurate. This procedure represents an artificial forcing of response into two opposed types. Second, the decision of a base for statistical treatment of each item must in this case be made by the experimenter or appeal to a limited committee. Third, the language difficulty leads to more serious error in the simple questionnaire than in any other form of measurement. In a response with a greater variety of possible returns, the words used may be misinterpreted, but that may cause a variation of one point to five or ten or more possible responses, while in the simple questionnaire it may mean a complete reversal of response, that is, 100 per cent. For example, in the religious attitude questionnaire of Professor Bain, there was a probable large misunderstanding of terms regardless of simplicity of statement. Difficulties of vocabulary arise due to varying concepts for the same term. Thus,

[15] Shuttleworth, F. K., "A New Method of Measuring Character Traits," *Sch. and Soc.*, 1924, 679.

[16] Meier, N. C., "Public Opinion," *Am. Journ. Soc.*, 31: 199–212.

[17] Case, A. T., *Liberal Christianity and Religious Education.*

[18] Achilles, Paul, *op. cit.*

[19] Symonds, P. M., "A Social Attitudes Questionnaire," *Journ. Ed. Psy.*, 16 : 316–322.

[20] Bain, Read, "Religious Attitudes of College Students," *Am. Journ. Soc.*, 32 : 762–771.

[21] Ream, M. J., "A Social Relations Test," *Journ. Appl. Psy.*, 5 : 69–73.

in a test such as that of Professor Bain, dealing with religious attitudes, it is impossible to determine the proportion of inconsistency in answers due to misunderstanding of terms, and that based upon a real conflict of attitudes in the mind of the student. In the results, I note that 67.2 per cent hold that God is an impersonal force, and yet 38.3 per cent of that same group hold that God interferes by providences and miracles. The inconsistency may proceed from language difficulty. It is obviously vital to the validity of the test to note the cause of this variation.

Another form of questionnaire is that which asks for a brief essay rather than an unequivocal answer of "yes" or "no." Professor Leuba used this form in his investigation a decade ago as to the attitudes of college students and men of science on immortality and belief in a personal God.[22] The answers from a thousand subjects were tabulated and placed in graphic form. In this type of questionnaire the judgment as to meaning and assortment of answers rests with the investigator. It will provide an unwieldy bulk of material, but has value in the development of a scaled type of response which may serve as a basis for further investigation with a check questionnaire. That is, from this bulk of a thousand returns may be chosen five or ten responses on each item. These may then be arranged in a scaled order for presentation to the subjects. I find no use of this arrangement before that of a test devised by Allport in 1925.[23] Recent usage of the questionnaire with essay response is found in the study of Achilles on the effectiveness of social hygiene literature, and by Hartshorne and May in testing the knowledge of right and wrong.

A fourth general method of approach has been through the use of word tests. Of these there is a considerable variety. Hart devised a socialization test based upon a word cross-out test.[24] A similar method was used by Coe in measuring opinion on public-

[22] Leuba, J. H., *The Belief in God and Immortality.*

[23] Allport, F. H., and Hartman, D. A., *op. cit.*

[24] Hart, H., *A Test of Social Attitudes and Interests.* Univ. of Iowa Studies, 1923, No. 4.

spiritedness,[25] and by Shuttleworth also in measuring money-mindedness.[26] These tests consisted of columns of words containing a number of words which might be expected to arouse opposition, or to be annoying or distasteful to the prejudiced subject. Watson later used a test of this kind as one part of his measurement of fair-mindedness.[27] While tests of this kind may be suggestive of some sort of emotional set, there are a number of difficulties involved in their use. The indeterminate base and the skewing of results, due to the forcing of opinion into two artificial groups, apply here as they do with the simple questionnaire.

Another use of word tests may be illustrated by the Van Wagenen American history scales.[28] Here the subject is presented with a situation, written in essay form by the experimenter, and asked to pronounce judgment upon it on the basis of a list of suggested adjectives. This test offers the distinct advantage of presenting a concrete situation for judgment rather than asking for a return on the basis of an abstract principle. A sample question follows:

"Two American soldiers, Jasper and Newton, returning from scouting duty, were told that a man who had left the King's cause had been captured by the British. Eight guards were now taking him to Savannah, where he was to be hanged the next day. They hastened toward a spring a few miles from Savannah, where the guards would be likely to stop to get a drink. When the British came to the spring, they stopped to get a drink. Two of the guards were left to watch the prisoner. The rest stacked their guns against a tree. Leaping from their hiding place, Jasper and Newton each snatched a gun, shot the two guards and seized the rest of the muskets. The six unarmed guards surrendered and were marched along back to the American camp with the rescued prisoner.

"Draw a line under the three of the following words which you think best describe this action of Jasper and Newton:

selfish treacherous daring cruel spiteful timid fearful brave bold cowardly."

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[25] Coe, G. A., "A Study in Civic Training," *Ped. Sem.*, 29 : 205–231.

[26] Shuttleworth, F. K., *op. cit.*

[27] Watson, G. B., "The Measurement of Fair-Mindedness," Teachers College Contributions to Education, 1925, No. 176.

[28] Van Wagenen, M. J., *Historical Information and Judgment in Pupils of the Elementary Schools.*

Achilles also makes use of a word test by presenting a series of statements followed by descriptive adjectives, one of which is to be checked.[29]

A fifth general method of constructing tests presents to the subject a number of degrees of opinion prepared by the investigator for each item. This can be illustrated by the Bogardus attempt at measurement of opinions on racial "social distance."[30] Thirty-nine national groups are presented for rating on a scale of social distances, proceeding in scaled descent in seven steps, from admission to "close kinship by marriage" to "exclusion from country." A marked source of error here will result, no doubt, from inability of the subject to visualize the possibility of personal situations involving such choices with all of the rather extensive group, and yet, unwillingness to acknowledge, even under the cloak of anonymity, lack of any information, or experience, with regard to any one of the racial groups. This test was used in 1925 in connection with a race relations survey. In the same year, Dr. Lund used a scaled questionnaire in studying opinions of belief and disbelief in statements of social fact.[31] In this questionnaire, there was a list of twenty possible answers gradated in order of strength of belief ranging from "belief allowing for no doubt" at + 10 to "disbelief allowing for no doubt" at − 10. However, this test did not present actual statements of the possible twenty variations. Nothing was given but the scale of twenty positions, and the difficulty of attempting introspectively to divide any attitude into twenty hypothetical divisions, and then determine where self-judgment would place the person tested, must have been considerable strain upon the imaginations of those taking the test. Watson has used this form of test extensively in the measurement of fair-mindedness.[32] He has constructed degree of truth tests, inference tests, a moral judgment test, and a generalization test on this basis. His tests

[29] Achilles, Paul, *op. cit.*

[30] Bogardus, E. S., *The New Social Research*, pp. 212–216.

[31] Lund, F. H., "The Psychology of Belief," *Journ. Abn. Psy.*, 20 (1925): 63–81.

[32] Watson, G. B., *op. cit.*

vary from that of Dr. Lund in having the answers limited to five instead of twenty positions, which is probably all the differentiation that could profitably be made introspectively on the statements made. In addition, the statement of each of the five positions is given in general terms such as "probably true, or probably false in large degree," etc. While this test is not comparable in its probable accuracy to those devised shortly afterward by Allport and by Thurstone, it represents a marked improvement over the order of merit, the sentence questionnaire, and the word tests. Hartshorne and May made considerable use of variations of this test in their measurement of knowledge of right and wrong.[33] A sample of their situation and response test follows:

"If you see a classmate cheating on examination
1. a. Say nothing to anyone.
   b. Explain to him that it is wrong and warn him.
   c. Report it to the teacher.
   d. Say nothing and try to cheat yourself."

One of these behavior possibilities was to be checked. As far as can be seen, they are not arranged in any order from one extreme of opinion to another.

A sixth general step in measurement of opinion was made by Allport and Hartman in the test devised to register opinion on seven political issues.[34] The issues were chosen and sixty subjects asked to write opinion on them in essay form. These reports were then analysed, and the relevant views chosen for each issue. These views were arranged by judges in scaled order. This differs from preceding experiments in the attempt made to establish an opinion variable in scaled order which would be subject to quantitative treatment. That this original arrangement was not an accurate statement of equidistant opinion variables was later shown by Thurstone, who refined the statistical analysis of the results.[35] But, this procedure did estab-

[33] Hartshorne, H., and May, M., *Testing the Knowledge of Right and Wrong.* Pamphlet.

[34] Allport, F. H., and Hartman, D. A., *op. cit.*

[35] Thurstone, L. L., "Attitudes Can Be Measured," *Am. Journ. Soc.*, 33 : 529–554.

lish a marked advance in accurate measurement. It was superior to the preceding tests, in that it provided: first, a series of possible choices on each opinion issue, whereas the simple questionnaire and the word tests provided only two; secondly, these choices were presented to the subject in definite form, thus rendering results capable of more accurate statistical treatment; thirdly, the opinion variables were taken from a cross-section of general opinion, rather than from the opinions of the authors or judges. Thus a more accurate preparation was provided in the construction of tests before they were submitted to subjects. The flaw in the graphic presentation of the results of this test, as on a basis of equidistant opinion variables, could not be recognized until after the tests were used, and this statistical error was rectified by Thurstone.

A further refinement in the construction of the scale might be suggested in the utilization of a large number of subjects, rather than a few judges, in determining by the order of merit method the position of the opinion variables on the base line. This would increase the probability of the opinion variables being placed on the base line in an order which will not be changed when the test is submitted to another typical group. Also, as the number of opinion variables on each issue increases, the amount of statistical error due to their not being equidistant on that base is decreased. That is, as the number of units increases, the amount of possible statistical error would decrease.

From our survey of the tests which have been used in the last ten years, in opinion measurement, the following conclusions emerge:

(1) Attitude cannot be measured. An attitude is a subjective state. Neither opinion nor any form of overt behavior is a certain index of attitude.

(2) Opinion can be measured, although the method used in measurement requires still further refinement.

(3) The order of merit method, the sentence questionnaire, the brief essay questionnaire, and most forms of word tests, are implements much too crude for this type of study. The essay questionnaire test, such as the Van Wagenen History Scales,

which provides for the choice of an adjective descriptive of the situation presented, has at present a limited auxiliary use. The order of merit method may also, at times, have auxiliary use.

(4) The most accurate test at present is one based upon a predetermined base of attitude variables presented in stated form to the subject. The increase in attitude variables on each issue, up to the point where these variables lose significance to a typical group, adds to the statistical accuracy of results. This point will vary with each issue stated and can be determined only through experimental use of the test on the issue in question.

The significance of results of opinion tests, as they achieve increasing accuracy, is obvious.

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PUBLIC CREDITS AND MASS-CONSTRUCTION AS A SOLUTION OF THE HOUSING NEEDS OF THE LOWER INCOME GROUP

S. JAMES HERMAN

With a Discussion by Lawrence H. Seltzer
And a Reply by the Author

ONE of the most important social problems of today is the housing of the family. Home ownership in the United States, particularly in the larger cities, shows a definite and progressive reduction in every census period, New York having fallen to 12.7 per cent and Detroit to 38.3. Further, the homes still remaining in possession of their occupants show a steadily rising encumbrance, clearly indicating that economic pressure with rising costs is largely responsible for the reduction in home ownership. With over 80 per cent of those gainfully occupied earning less than $1,800 per year, it is evident that any proposed plan must fit the needs of the lower income group.

Hence, this plan is intended exclusively for the family with an income of $150 per month or less; a class, which, under present conditions, is unable to buy or maintain a home and garden spot containing modern American improvements. A five-room frame house, containing such improvements, including lot, sells in Detroit at $6,500 to $8,000 on the deferred payment plan. Taking $7,250 as the mean, we have a monthly burden of about $90, including annual amortization of principal, which is far beyond the reach of the family earning from $100 to $150 per month. To bring this group under the stabilizing influence of home ownership, this monthly housing burden must be reduced to 25 per cent of their monthly income — or not more than $25 to $30.

The force of American traditions and the intricacies of our political institutions are recognized in laying down a group of controlling principles as fundamental to any plan, and the various elements built up to conform to these principles. They are:

1. The plan must function without charity or philanthropy.
2. It must work without the permanent expenditure of public money.
3. All houses must contain modern heating and sanitation, be durably constructed and faced with brick, stone or concrete, thus being subjected to a minimum of upkeep and depreciation.
4. Cost of construction must be brought down to the level of the budget limit of incomes as low as $100 per month and the carrying charge must not exceed the present rental expense.
5. As far as possible, it must not interfere with the economic status of various real estate and building interests; hence the benefits of the plan are limited to those families who have no hope of becoming home owners on a commercial basis. (England's experience, over twenty years ago, indicates that an effort in this direction is likely to stimulate the real estate and building industry rather than depress it, as it will encourage the wage level immediately above this class to build more and better homes.)
6. It must be strictly non-partisan, non-sectarian, and not be subjected to political influence or preferment; hence the state or any political subdivision thereof is excluded from participating either in the purchase or the development of the land.

To meet the rigid requirements of these principles, we are forced to take four important steps:

1. Eliminate the cost of financing by making ample capital available through public credits. This item alone constitutes 20 to 25 per cent of the selling price of the average working-man's home, purchased on the deferred payment plan.
2. Purchase land for cash in parcels of not less than 200 acres, thus reducing the cost of land.
3. Purchase materials in like manner, in quantities for not less than 1,000 homes, thereby lowering their cost.

4. Schedule the building program on a mass basis of not less than 1,000 homes per undertaking, thus forcing the cost of production to the lowest level.

Of these four advantages, the last three are well established and in common usage by many large concerns. The only one requiring particular discussion is — provision for ample capital through public credits and this, being the core of the plan, is left for later discussion.

From a study of financial set-ups in relation to the family budget, it was found necessary to reduce the cost of the average home to 40 per cent of its present selling price in order to bring it within the means of the $100 to $150 per month family. This seemed rather questionable, and the results of a careful and thorough investigation were more than encouraging.

In order to determine, in a definite manner, the cost of individual homes, if erected under this plan, a parcel of land containing 160 acres was selected on which to base this cost, after a number of pieces had been examined and priced. An architect, with city planning experience, was engaged to draft a model community plan suitable to the land selected. After providing for a business center, civic center, administration building space, one central park of ten acres, four smaller parks of about two acres each, school ground surrounded by playground, library location and four church sites, it was found that the remainder of the 160 acres would divide into 604 residence lots 50 by 135 feet each. (Note size of lots as compared with size of average subdivision residence lot.)

Plans and specifications were drafted covering all public utilities such as sewer, water, gas, electricity, telephone, paving, sidewalks, curbing, park development, tree planting, etc., including complete drawings and specifications of three types of bungalows, none containing less than two bedrooms. Part of the bungalows were to be finished in face brick and others in stone tile. Every aesthetic advantage was utilized in the treatment of land and architecture, with the idea of avoiding monotony in perspective, as well as drab sameness of duplication.

In addition to the improvements mentioned, these plans provided for a double tennis court in the center of each block. The object of such an arrangement, which the depth of the lots permitted, was threefold. In the first place, convenient access to the courts would stimulate interest in, and lead to the adoption of, the simple and inexpensive sport of tennis as the principal physical diversion of the adult as well as the child. Secondly, the question of safety was considered. If a ball was batted over the wire enclosure of such courts, it would not be necessary for the player to run into or across the street to regain it as is a common occurrence where courts are exposed to the street. Thirdly, the courts, which are not usually ornamental, would be out of sight.

Complete bids were submitted by two reputable firms of building contractors, which included a provision for ample surety bond for completion of the entire community within a period of two years.

In estimating the cost of the complete, individual home and garden spot, under this method, every precaution was taken, and all figures, bids, etc., were as carefully computed or submitted as if the actual construction were to be proceeded with immediately.

The results were surprising, for in spite of the fact that the community contained many features in the way of improvements and embellishments not to be found in the average residential subdivision, it was found that these homes, with all modern and sanitary conveniences, could be produced at slightly more than one third of the normal market-selling prices of similar houses built individually.

An analysis of the great difference between the cost arrived at and the normal market price was then undertaken, and it was not difficult to establish and allocate the various items, as indicated in Table A. Table B gives a detailed summary of the items composing the total development of the community. Figure 7 shows landscape plan.

With the physical basis of a suburban garden community established, it was but natural that our next step would be to

socialize it, and we included all important phases of community life that would assist, (1) in counteracting anti-social tendencies; (2) in furnishing a complete change of environment for the worker at the end of his day's toil; (3) in separating the younger generation from the great temptations of a modern city; (4) in inculcating in the foreign-born element of the community the American concepts of personal responsibility and democratic government.

To realize these aims, the plan provides for the essential individual and community needs of the families, yet keeps within its budget limits.

A system of administration embracing all important community activities has been outlined in detail. It is intended to function without outside interference, subject, however, to the laws and ordinances of the city or county in which it may be located. Particular emphasis is placed on the desirability of drafting the services of every available resident for some form of community responsibility, thereby enhancing the spirit of interest and common fellowship. The plan embraces the idea of guidance rather than meddling, and finds a niche of social activity for everyone capable of contribution. Such things as community welfare, chest, loan fund, health, accident and life insurance (in case of the death of the bread-winner, home reverts to the family, fully paid), and other elements which are likely to increase community solidarity are provided for.

To provide ample capital at reasonable rates of interest, public credits must be made available through a state constitutional amendment. Twelve states have enacted various forms of housing aid, and four, Massachusetts, Texas, North Carolina and South Dakota, passed constitutional amendments involving housing helps and financial assistance far in advance of anything proposed by public credits.

The Michigan legislature will be requested to initiate a state referendum. It will require about three years before the amendment can be submitted to vote, and this will give ample time for a thorough discussion of the merits of the proposal.

The principle of public credits is not socialistic or radical.

Rather, the housing conditions in the modern industrial centers have so radically altered that families of the lower income group find it impossible to obtain housing facilities that will measure up to American standards of living.

Careful consideration has been given to the various methods of financing adopted in the past, and none of these was found adequate to meet the economic needs of the problem. Semi-philanthropic limited dividend companies have made substantial progress and have conclusively shown what can be accomplished with ample capital and the right public spirit behind it. Unfortunately, these have not met, and never can meet, the housing needs of the people. They are excellent in pointing the way, but so far, none has gone beyond the completion of a single undertaking.

The City Housing Corporation of New York, the most outstanding success of this type, though organized in 1922, to date has failed to complete the construction of Sunnyside, owing to its inability to raise additional funds, and this has occurred in spite of the fact that it is well sponsored and located in the wealthiest city of our country.

In the metropolitan area of Detroit, we could use today fifty communities of 1,000 homes each, and an addition of one to three such communities annually to accommodate the influx of new residents.

The proposed measure for public credits is intended to operate on a regional basis. A county or group of counties may be permitted to create a home loan fund. As an example, the counties of Wayne, Oakland, Genesee, Washtenaw and McComb may unite in establishing a common home loan fund under a special act of the legislature providing for its management and operation.

Home Loan Commission

The governor will appoint a home loan commission of public-spirited men who will serve without compensation. The power of this commission will be limited to the administration of the fund, issuing of home loan bonds, to be amortized serially over

a period of 20 to 30 years, and loaning the proceeds to housing corporations at a rate of interest sufficiently high to pay the cost of maintaining the home loan department, and providing proper methods of repayment of said loans. The loan commission will be a legal instrumentality of the community creating it and will have the power to pledge the faith and credit of such community.

Housing Corporations

The housing corporations will be organized wherever they are required or wanted and will be the only ones empowered to buy land and build communities. Each will constitute a separate corporate entity, the same as any other business corporation, and will be responsible for its own acts and deeds, and will operate under a special charter which will provide proper safeguards, restrictions and limitations. The city or county in which they are located will not be financially responsible for its undertakings, although its members will be appointed by public authority in the same manner and on the same basis as the loan commission.

Assuming the loan commission as actually functioning, the cities of Ann Arbor, Detroit, Flint or Pontiac desiring to undertake a community building project will appoint a group of citizens to initiate the formation of a housing corporation, which, after being duly organized, will borrow from the loan commission, giving a mortgage on all property purchased, including improvements; will buy not less than 200 acres of land and proceed with the construction of a community through its executive personnel.

It will have full discretion in its choice of applicants for the purchase of homes, and will use every care in the selection of the residents in order to assure reasonable amalgamation of various racial stocks.

While the majority of purchasers will be required to make an initial cash payment, it is hoped to scale these in such a manner as to permit some of them to pay in accordance with their ability and others with personal services in lieu of cash. The balance due will be amortized by monthly payments which will include

principal, interest, taxes and assessments for various community activities previously discussed.

Particular thought has been given to the large family whose needs and capacities to meet them are usually in inverse proportion. Such families are likely to be in very straitened circumstances and require a maximum of floor space. A flexible type of house has been planned, permitting later additions, subject to definite plans and specifications, thus enabling the occupant to complete such house with his own labor and at his own convenience.

Various safeguards have been carefully considered in connection with the operation of the loan commission and housing corporations, and include all reasonable provisions relating to the financial, legal and sociological aspects of the proposal.

It is not possible within the space of time allotted to take up a detailed discussion of the various phases of the plan, and we must content ourselves with the conclusive statement — that there is positively no way of meeting, speedily, the urgent need, without public credits in some form. It has been suggested that wages should be increased to enable the family to be decently housed. In our opinion this is not economically feasible and, if it were, the prices of dwellings would rapidly rise in proportion to the increase in wages and would be as far out of reach then as now.

There is but one practical way of meeting this problem, and that is by bringing the cost of a home with American standards down to the wage level of the group under consideration, and this can be done only through the methods outlined herein.

Detroit, Michigan

TABLE A*

SAVINGS EFFECTED BY MASS-CONSTRUCTION, WITH AMPLE CAPITAL, AS COMPARED WITH NORMAL COMMERCIAL PRICE, ON DEFERRED PAYMENT PLAN

Selling price		$6500.00
Contractor's profit at 15% on sale price of $6500	$ 975.00	
Appraisal, abstract, legal fees, etc.	37.50	
Fee for builder's loan (loan $2500)	75.00	
Bonus for permanent mortgage (mortgage $2500)	75.00	
Interest and insurance charges before property is sold, approximately	30.00	
Discount on sale of builder's equity of $6000 (selling price $6500 less down payment at 20%)	1200.00	
Salesman's commission 5% on $6500	325.00	
Contractor's excess, paid on account of buying material, etc., on small quantity basis (bungalow No. 2, $1989) at 10%	198.90	
Syndicate's profit and overhead, consisting of commission of subdividers and salesmen when land was originally subdivided (25% on $1800 † used as selling price of lot — $450 and 100% on actual cost of lot — $659.61)	1109.61	
Total loading	$4026.01	
Actual cost of house and lot (bungalow No. 2, $1989, lot $659.61) and all improvements	2648.61	
Approximate selling price (ordinary commercial method)		$6674.62

* This tabulation of costs does not include basement or central heating plant, having been designed for use in Los Angeles. Approximately $500 should be added to cover these two items.

† This is a very low estimate, as a lot containing all the aesthetic improvements indicated would readily sell for $2500 or more.

TABLE B

ESTIMATED COST OF DEVELOPMENT OF MODEL SUBURBAN COMMUNITY

Land: 160 acres at $1200 per acre		$ 192,000.00
Paving: 175,000 sq. yds. (5 inches of asphaltic concrete) at $1.21½ per sq. yd. (City of Los Angeles quoted $1.35 less 10%)		212,625.00
Curbing: 35,500 lineal feet at 45¢ per foot (City of Los Angeles quoted 50¢ less 10%)		15,975.00
Sidewalks: 141,000 square feet 4 feet wide at 11.7¢ per square foot (City of Los Angeles quoted 13¢ less 10%)		16,497.00
Sewers: 24,000 lineal feet at $1.12½ per foot (City of Los Angeles quoted $1.25 less 10%)		27,000.00
Water mains: 24,000 lineal feet at $1.60		38,400.00
Fire hydrants: 40 at $75.00 each		3,000.00
Trees (residence portion)		1,200.00
Septic tank (if required)		5,000.00
Primary development of parks		10,000.00
Busses: 5 at $8,000 (if required)		40,000.00
Initial management, advertising, overhead, etc.		25,000.00
Possible emergencies		25,000.00
Gross cost of tract and improvements		611,697.00
Less sale of 500 feet business frontage at $100 per foot	$50,000	
Less sale of 500 feet business frontage at $150 per foot	75,000	125,000.00
Net cost of tract and improvements		486,697.00
300 bungalows, model 1, at $1,284.30	$385,290	
150 bungalows, model 2, at 1,989.00	298,350	
154 bungalows, model 3, at 2,308.50	355,509	1,039,149.00
Total cost of development		$1,525,846.00

DISCUSSION

By LAWRENCE H. SELTZER

NO ONE who studies the facts can deny that there is a serious discrepancy between present-day standards of decent housing and the actual housing accommodations available for the lower income groups of our population. This discrepancy is the hous-

ing problem. It exists in all the larger cities of this country, and is even more acute in the older countries of Europe. Why does it exist?

In its more general aspects, at any rate, the housing problem is one of poverty. According to present-day American standards, there has always and everywhere been inadequate, bad housing. Do we have overcrowding today? We have had it for many generations. Housing is expensive; it requires relatively large quantities of capital; except in rural districts, it must have relatively expensive land; and today we demand far more in the way of housing than we have ever demanded before. It is not surprising that the mass of urban workers do not earn enough to command, under ordinary conditions, what we now consider to be decent housing.

Time was when a house was an independent and rather rude shelter. It was built on what we may call raw land. The house-builder procured water by drilling an inexpensive well. He provided for sewage disposal in a simple manner. He cleared a small piece of roadway. The interior of his house was roughly finished, or, at any rate, the finishing was done largely by the builder and over a period of time.

Today, half of our population lives in cities. Urban land costs are high. They mount higher steadily. And the land can no longer be used raw. There must be paved streets, sidewalks and curbing, sewers and water-mains, open park places, transportation facilities. The houses can no longer be rough shelters. They must conform to certain building code restrictions. In most parts of the country, practice requires that they have water-proof basements. They must be wired for electric lights, piped for gas and water and plumbing. They must be finished inside with considerable wood trimming, papered and painted and otherwise decorated. And they must bear substantial charges for various municipal or public utility services: police and fire protection, recreation facilities, lighting, gas, water, sewage. An urban house today is far more than four walls and a roof standing on a piece of rough land.

Consider for example the model suburban community planned

at minimum cost by our own Dr. Herman. One hundred and sixty acres of raw land are purchased for $192,000. (Within a fifteen-mile radius of Detroit, this land would cost $240,000.) Paving, sidewalks, curbing, sewers, etc., add at the minimum (10 per cent below city charges) $330,000. The land raw costs $192,000. Ready for building, it costs $522,000.

The first point that I should like to make, then, is that part of the discrepancy between our housing standards and our housing achievements for the mass of our workers — part of the housing problem — is due to the higher standards now demanded, standards forced upon us in large measure by the increasing urbanization of our population. It may be true, in other words, that we cannot afford the housing we desire.

It is contended, however, and with reason, that the housing problem is not entirely a question of poverty. Dr. Herman contends that two special factors, amenable to social control, are responsible for perhaps fifty per cent of the present cost of working-men's homes. These factors are: (1) the high cost of financing; and (2) the avoidable wastes in the construction industry. Dr. Herman believes that by making the public credit available for home-construction, and by mass-construction, he can bring the costs of working-men's homes down within the economic power of the lower income groups, otherwise unaided, to own them. Such a policy, in his opinion, would involve no permanent use of government funds, no charity; it would merely correct one of the deficiencies of competitive industry without involving undesirable ulterior consequences and without any real redistribution of income.

It is not my purpose to oppose such a policy. I am, in fact, sympathetic with it. Important savings may result from it. Nor shall I spend time in considering the social aspects of the general question of government versus private activity. I desire to confine attention for a few moments to a consideration of some of the implications of the use of public credit for housing.

In the city of Detroit it is true that financing charges, particularly the costs of providing the capital that is secured by subsidiary liens on houses — second mortgages and land con-

tracts — are extremely burdensome to the house buyer. They do actually constitute from 15 to 25 per cent of the total purchase price. Why are they so high? (1) Because of the real risks involved. A down payment of 10 per cent or less covers the builder's profits and the costs of selling, but it leaves little or no margin of safety to the holder of the subsidiary lien. The workman who buys a house may lose his job; if his monthly payments stop, the lien holder is forced to carry them. It rarely pays him to claim the house: an idle house deteriorates rapidly. In periods of industrial recession — and seasonal recessions are common in the city of Detroit — the house cannot be sold readily, for many workmen are out of jobs. (2) A second reason why financing costs are so high is that neither houses nor the securities issued thereon are sufficiently standardized to permit a ready market for them. The bond of a large railroad, or even of a large apartment house, has a relatively quick, close market. The market for land contracts and second mortgages, on the contrary, is of a very loose character. Each unit is unique, requires separate investigation, and there is no standardization in the amounts of funds required.

Would these factors be eliminated by the substitution of public for private credit? Partially. The pooling of the risks attached to individual houses and purchasers and the substitution of standardized government obligations for the unstandardized obligations now employed would undoubtedly permit a great reduction in financing charges. They could not, however, eliminate all the risk elements that now make for high charges. There would have to be a considerable spread between the rate at which the government borrows and the rate at which it lends, unless, indeed, it is frankly conceded that government-aided housing construction is not intended to be fully self-supporting.

Now what is implied by a policy of providing government credit for home-construction? Our first consideration must be the magnitude of the enterprise. If substantial results are to be obtained, the policy must be carried out in substantial fashion. Indeed, if it is to provide ample housing for all those now inadequately housed, it must be of huge proportions. And

if it permits great savings in costs, a large proportion of the housing now annually supplied on a commercial basis would have to be undertaken by the government. In 1924, the latest year for which I have full figures, 269 cities reported new residential construction for a total of 455,429 families, at a cost of nearly $2,000,000,000, exclusive of land and its improvements. The latter adds one fourth to this investment in housing. In the city of Detroit, alone, during 1924, houses and apartments for 25,752 families were constructed at a cost of approximately $100,000,000 exclusive of land, or at the rate of approximately $4,000 per family exclusive of land. Lower costs might stimulate more construction. Since at least two thirds of the wage-earners are considered to fall within the lower income groups, the fiscal operations required for a thorough-going policy of public credit for housing would have to reach gigantic proportions. How much cities, counties, and states could borrow without injuring their credit, and thus raising rates and restricting the credit open to them for other governmental purposes, is a question. And since the stimulus of lower costs and government credit might result in larger amounts of construction than otherwise would be undertaken, there might be a marked diversion of capital from other uses.

The housing problem is most acute in the larger cities, or at least most conspicuous. It seems reasonable to suppose that urban rather than rural districts would avail themselves most of the opportunities for public credit and mass construction. This would tend to add to the advantages of urban as contrasted with rural residence. Approximately one half of our population already lives in cities. Is it wise to place a further premium upon city residence? Does not the housing problem result in large measure from the congestion of population within small areas?

This raises a question that is at the heart of the housing problem, and one which, peculiarly enough, is not considered in the proposal advanced by Dr. Herman. I refer to the question of land utilization. I have already pointed out that platted city lots are two and one-half or three times as expensive as the same land without improvements. We now have to consider the al-

most unremitting increase in urban land values. The rule of thumb of real estate men puts the rate of appreciation at 3 per cent a year. The New York State Housing Commission reports that land in the congested but poor tenement districts of New York cannot be purchased for much less than $1,000 per front foot. The Metropolitan Life Insurance Co. constructed a group of model apartments on so-called cheap land, costing $100 a front foot. Employing the minimum cost figures of the Metropolitan, the Commission found that the difference between $100 land and $1,000 land meant a difference in cost of $564 per room, or a difference of $2,256 in the cost of a four-room apartment. If land utilization and land values are allowed to take their natural course, I can see little hope in the single home, however cheaply constructed, as a solution of the problem of urban housing; apartment houses or tenements alone can make efficient use of expensive housing sites. For, with the continuing growth of population and of cities, land values are bound to increase. Suppose we did effect enormous economies in finance and construction by government aid. Each few years we should find cheap housing once more beyond the means of the working classes because of the growth of land values. Those who had purchased government houses earlier would profit; but the new ranks of would-be home purchasers would still find housing beyond their means. If we are to tackle the housing problem in collective fashion at all, control over land appears to me to be an indispensable element in any far-sighted policy.

Even Dr. Herman's scheme would require a measure of land regulation. Suppose the government could provide good housing at half the commercial cost. Unless it provide it for all who ask it, the government houses would have a market value above their original selling price. A worker might buy a government house at $4,000 and sell it a few months later for $5,000. Obviously, some limitation of purchase and sale would have to be made. The mere fact that a given piece of land has been developed and built up increases the value of the homes and site far beyond cost.

I began my discussion by saying that the housing problem is

in large part a problem of poverty. I meant that adequate housing of present-day urban standards cannot be sold to the lower income groups at prices within their means, unless, indeed, the project be subsidized. Let us analyze the figures further. The Shipbuilding Board in 1918 bought raw land, developed it, and built working-men's houses at cost, exclusive of certain costs of administration. The costs were something more than $4,200 a house. The Metropolitan Life Insurance Co., we have noted, constructed model tenements. The cost per room, without carrying charges and without the land, was the equivalent of $858 of 1925 building dollars, or $4,290 for five rooms without land. Let us suppose land and cottage could be provided by government for $4,000. Could a $1,500-a-year worker buy and carry such a house? Six per cent interest would require $20 a month; taxes at Detroit rates and standards of assessment at least $5 more; fuel and light another $5; and insurance and repairs, at least $2 more. Without provision for amortization or full allowance for depreciation, the carrying charges would amount to $32 a month. Give the purchaser 25 years in which to amortize; he would still require $13.33 a month for principal payments. If one allows for reductions in interest charges concomitantly with principal payments, his net monthly outlay, nevertheless, could not be much smaller than $40 a month. Given our existing irregularity of employment, and the prevailing wage scales, I cannot see how the lowest income group could carry this charge without sacrifice of food, clothing, and schooling for children, or without the same resort to lodgers and "doubling up" that now enables them to pay urban rents.

What I have said is not an argument against the use of public credit for housing. I am, as I have said, sympathetic with the project. I do not believe, however, that economies in financing and construction alone can bring urban housing of present-day standards within the means of the low income groups. If we should decide that the provision of decent housing is a fundamental duty of government, we shall have to go much further. Frankly or in disguise, we shall have to subsidize.

College of the City of Detroit
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REPLY

By THE AUTHOR

Dr. Seltzer's chief contentions are, that:

(*a*) Poverty is largely the cause of bad housing conditions.

(*b*) Government land value control in some form is essential to the solution of the housing problem.

(*c*) Government subsidies are inevitable if we are to supply modern housing for the low income group.

Replies to chief contentions:

(*a*) Poverty is not a correct application to a self-supporting family; rather lack of economic balance between earnings and cost of modern housing.

(*b* and *c*) Public land value control and government subsidies may or may not be advisable. I endeavored to take conditions as they are and applied a practical solution rather than enter into a discourse of theory and probability.

Replies to miscellaneous criticisms:

(1) In arriving at cost of homes, if constructed on mass-production basis, in Los Angeles, $1,200 per acre for raw land was used. This was the actual price at which 160 acres, situated seven miles east of industrial area, could be purchased. From investigation, it is found that there is still ample acreage available within a radius of twelve miles of Detroit's industrial areas at prices much below $1,200 per acre. Raw land can be obtained within five miles of the industrial areas in any of the other manufacturing cities in the state at prices much below this figure.

(2) My plan cannot be construed as a "Government versus Private Activity." It should be noted that neither state, county or city will have anything to do with the purchase of land or the development of communities. This has been carefully eschewed.

(3) Discount basis, on which land contracts covering working-men's homes are sold, is from 20 to 40 per cent, rather than

15 to 25 per cent; hence a mean of 25 per cent is conservative.

(4) Under the present method of financing, building and selling homes, it is true that considerable risk is involved, due to unemployment, sickness or other contingencies, which are today making demands for help, and are being supported by public welfare agencies. Under the plan proposed, monthly payments will be greatly reduced, first, on account of much lower sale price, and, secondly, as a result of a longer period of amortization. This lesser monthly burden will materially reduce this risk. In addition, my plan proposes that a sum shall be added to the selling price of individual homes to create an emergency fund. Further, monthly payments will include a charge in addition to amortization of principal, interest and other carrying charges, to provide for group life insurance sufficient to cover unpaid balance of individual homes, community chest and special community loan fund, which will not only reduce the risk further, but will also reduce the demand on public welfare agencies for aid.

(5) This plan will interfere little, if any, with various economic interests in this field. It is intended to limit the benefits of this project to an income group who cannot buy homes under prevailing commercial prices and terms. Hence it will not take away, but add to, building activity.

(6) Table No. 26, page 134, "Income in the United States" (National Bureau of Economic Research, 1921), gives the following:

Incomes of	$1,800.00	and	under	per	annum	81.99 %	of	total
"	"	1,200.00	"	"	"	"	54.51 %	"	"
"	"	1,000.00	"	"	"	"	38.74 %	"	"

(7) Regional public credits will obligate counties only within the region, and not urban municipalities. Wayne and adjoining counties have a bonded debt of only approximately one tenth of 1 per cent, whereas their borrowing limit is 3 per cent. Use of city credits was purposely avoided, owing to heavy debt burden already carried by most of them.

(8) Possibility of diversion of capital from other sources, if building operations are stimulated largely, does not seem economically sound. Compiled totals of building operations are today used as a definite criterion or index of general business prosperity. Increment in building operations is bound to reflect favorably in other channels of industry.

(9) Decentralization and stimulating of outward flow of those already in congested areas as well as for new migrants cityward is the objective of the plan.

(10) By developing suburban communities, we are taking the most rational step in checking the continued rise in land values in centralized areas, and curtailing apartment and tenement construction. It is true that apartments and tenements alone can make use of expensive sites. This, however, is exactly what I wish to discourage and prevent in the future. Apartments and tenements are unfit places in which to rear families. The single family dwelling is the accepted ideal of family environment.

(11) Control of re-sale, to prevent profiteering, can be accomplished through: (*a*) control clause in land contract, compelling specified number of years residence, thus entrenching individual family in community interest and activities; (*b*) competitive selling by housing corporation in the same or other contiguous communities; (*c*) forming community stock corporation and providing in stock certificate certain definite plan of re-sale as was practiced in Yorkship Village, now Camden, New Jersey.

(12) The average cost of $4,000 per home mentioned by Dr. Seltzer is too high, for it would require a gross income of $160 per month to carry a home at that price. Under the plan proposed, and from thorough investigations, I am sure homes can be sold at prices as low as $2,800. At this price it would be possible for the family with an average income of $100 per month to carry the monthly burden, especially on a long period of amortization.

(13) The larger families with lesser incomes are likely to live under the worst housing conditions now, hence their re-

moval to a community with ample sunshine, air and play space, would fully compensate any curtailment in food, clothing, and the like.

(14) American traditions have never been favorable towards direct subsidies, but I am quite sure that opposition to the plan from this angle will be slight, since it proposes temporary use of public credits only and not gifts of public money.

ECONOMIC ASPECTS OF MODERN SPEED

SAMUEL M. LEVIN

NO ONE has presented the case for the speed tactics of modern industry with greater fervor than Mr. Ford. "The spirit of crowding," he writes, "forces the man who has the qualities for a high place eventually to get it. . . . Pressing always to do work better and faster solves nearly every factory problem."[1] Through this spirit, then, worker and business may aspire to salvation. To some this view may signify nothing more than self-assuring rationalization of current practice. Yet it is true that industry has made speed a factor of immeasurable significance in contemporary life.

From the industrial point of view, modern speed implies the pressure to extract the most in physical achievement from a given unit of time. From the point of view of its incidence on man, the speed problem concerns itself with the growing tendency to an acceleration in the velocity of living. It is seemingly a by-product of socio-economic evolution, gaining its ground stealthily and without any noticeable premeditation. Yet so widely pervasive is its influence in business, in the factory, and even in the leisure moments of life, that one is justified in taking pause to understand it.[2]

From the remote past to the advent of the era of commercial

[1] Ford and Crowther, *My Life and Work*, pp. 97–98.

[2] "To be busy has been with us a primary virtue, and even our play has had to find a place for itself as a kind of business." — Irwin Edman in *Harper's Magazine*, Jan., 1928, p. 221.

The thought that the very leisure released by the shorter work day may be a contributing factor to modern speed is interestingly hinted in the following: "It may be that the speed and restlessness which have become commonplaces of the 'modern world' and of the younger generation can be traced partly not to war, nor the automobile, nor the movies, nor prohibition, but to the greater amount of time which the world now finds on its hands." — Editorial in the *New York Times*, Dec. 30, 1925.

and industrial expansion, life seems to have moved at a slow pace. Indeed, there was little reason to expect a sharp change in the old ways of life, before invention, specialization, competition, and efficiency, together with improved technical apparatus of production and transportation, became realities of everyday existence. Thus it appears that there were no watches before the sixteenth century, and that the second hand was not introduced until the closing years of the century following. Yet modern industrial efficiency "rests on accurate and scientific study of unit times."[3] It is evident that for this cause alone little could be accomplished in measuring speed, the element, according to Frederick W. Taylor, "most vital both to employer and employee."[4]

During the medieval period men turned to economic activities merely to provide themselves with a livelihood after the needs of their station. Enterprise was not then the road to great wealth or power as it is now. With a limited sphere for the investment of capital, the animus of the Church against interest, the prevalence of agricultural occupations, and the constraining influence of tradition and social fixity, a hurried existence would be anomalous, to say the least.

At the present time the word "speed" projects before our eyes the usual scene of people and things mixed in an indescribable welter of activity. But this is the external aspect of the matter. From the angle of American experience, the term relates itself to a complex of activities that interfuse with the very life of the business organism. These may be listed as follows:

1. Pressure to increase production. This is bound up among other things with modern industrial management, the multiplication of time-saving devices, the use of high speed machinery,[5] and the policy of unstinted mechanization.

2. Competitive buying and selling, kept efficient by quick thinking, promptness, and "punch."

[3] F. W. Taylor, *Shop Management*, p. 58. [4] *Ibid.*, p. 45.

[5] "Now high speed cutting steel has come and our cutting speeds have increased from 25 feet (per minute) to 500 feet or more." — H. A. Coffin in *Proceedings of the National Safety Council*, 1923, p. 174.

3. The effort to make or break records, as exemplified by individual, departmental or factory output, volume of monthly or annual sales, hewing down of costs, increasing profits, etc.

4. The constant tendency for business or industry to expand, placing a premium on stimulating policies that speed up the process of growth.

5. The idealization of quantity. This is fixed in peoples' minds by such impressive facts as the growth of cities like Detroit or Chicago, a fortune like Ford's, an industry like the radio or automobile industry, a mail-order house like Sears Roebuck. There is generally an eager responsiveness on the part of the American public to the argument of great size, weight, length, speed, or cost.[6]

6. The urgent striving for pecuniary success.

7. The growing dependence on a miscellaneous and highly efficient apparatus for transportation and communication.

8. The volume and variety of consumers' goods, urged on all classes of purchasers through blatant advertising appeals, ingenious salesmanship, changing styles, rising standards, cut-rates, small down payments, etc.

9. Increasing mobility of population with its succession of change, due mainly to economic uncertainty, the lure of the city, and the automobile.[7]

[6] A folder describing a new subdivision about a dozen miles from Detroit, put out by a successful real estate firm, is captioned by these words: "Detroit is the fastest growing city in the world. The finest superhighways, the greatest single street real estate development, the tallest hotel and the largest office building in the world are in Detroit. . . ." Detroit, in fact, has had a phenomenal growth. In 1890 the area of the city was 22.19 square miles, and the population 205,000. In 1925 the metropolitan area exceeded 200 square miles, and the population reached 1,500,000. Nevertheless a Convention and Tourist's Bureau engaged in a campaign to make Detroit the first convention city; and its full-page advertisement urging contributions to the fund, contained the following: "Let's make Detroit a 2,000,000 city by 1930. It can be done. All we have to do is to tell the world about our peerless city. . . . Twelve hundred citizens who are keen to build up Detroit are taking off their coats to make this a bigger and wealthier city." — *Detroit News*, Sept. 17, 1925.

[7] "There are children who grow up spending more days on the road than they do in houses. The state of Oregon is so concerned over the future of these little wanderers that it has actually made the experiment of putting a

It is evident that these conditions are of sufficient importance to make haste, or what has been called "the spirit of crowding," an attribute of national character. "All his life," Santayana remarks, "the American jumps into the train after it has started and jumps out before it has stopped." The added comment that he never once gets left behind or breaks a leg may perhaps be doubted. Even the new Ford prides itself on its unusual speed for a low-priced car, "because," as the advertisements say, "present day conditions require unusual speed." A well-known business magnate dilates gleefully on the new burst of speed, which will cause us "to eat faster, drink more quickly, and get up earlier and faster in the morning." Blood-curdling attempts are made to beat Major Segrave's famous Daytona Beach speedway record of 203.4 miles per hour. A recent press report informs us that a New York movie house "has installed a rapid fire shoe-repairing shop. Patrons are furnished with slippers, and while they sit and watch the pictures, their soles are mended." The psychologist John B. Watson regards the speed with which young people meet and mate as one of the most terrible tragedies in modern life, and a well-known American philosopher discerns in the phenomenal vogue of outlines at the present time the hurried business of getting short cuts to knowledge.

There is then the contemporary economic structure with its demands for specialization, technical efficiency, competitive skill, and command of the selling arts. The characteristic expression of these things in the factory and office are time rates and scheduled performance. The work itself, divested in the main of initiative, thought, or creative interest, and reduced to its utmost simplicity in terms of repetitious muscular movements or mechanical tasks, becomes easily measurable by time-rating methods. This pulverization of work permits not only of perfection of special machinery dealing with each minute part, but makes the job peculiarly amenable to fixation in terms of time-schedules. The saving of time becomes the great de-

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school in an auto camp." — "The Gasoline Gypsies," *The New Republic*, August 11, 1926, pp. 324–325.

sideratum, and a powerful economic motive is created for resorting to every species of ingenuity to attain this end.[8]

Back in the middle of the eighteenth century Benjamin Franklin had already declared that time is money.[9] In his *Autobiography* he offers this bit of illuminating advice regarding the sixth of his thirteen virtues, industry. "Lose no time; be always employed in something useful; cut off all unnecessary action." The appreciation of the utility of thrift is of course a commonplace in the business world today, and time as an entity with sacred rights of its own is even intrenched in economic theory, where it takes the form of reward for waiting or the exchange of present goods for future.

Thus our industrial order contrives by every means in its power to torture each moment of time to yield its utmost in product.[10] The deity of the machine, someone has said, is the capacity factor. The same deity rules over the plant or industry as a whole. The pressure of overhead costs on unused capacity, the impulse to expand, to beat previous records, to pile up profits — these seem destined for some time to come to force a continuance of the characteristically furious pace. Or the pace may be speeded up, and American industrialism will do what, according to Keynes, the German industrial machine

[8] Mr. Cady B. Durham, vice-president of the Buick Motor Co., explains the remarkable success of his company in making 1400 per cent more cars with 10 per cent more men, in 15 years' time, by the following: "The showing is due entirely to putting the stuff through faster, using conveyors and automatic machinery, and scheduling it so exactly that we eliminate storage." — *Magazine of Business*, July, 1927, p. 31.

[9] Benjamin Franklin in a paper entitled "Advice to a Young Tradesman."

[10] It is interesting to note in this connection that Taylor's gang boss, among other things, must show his men how to set their work in their machines in the quickest time, and the speed boss not only must advise his men how best to do their work, "but must see that they do it in the quickest time." — F. W. Taylor, *Shop Management*, p. 101.

A recent expression of the proper point of view for industrial executives is the following: "Have you conserved to the fullest extent possible the time of your mental and physical workers, the time of your equipment, tools, and facilities, the time use of your floor space, the time use of your material in stock and in process, and of the money invested by you and in you?" Quoted by Bye and Hewett in *Applied Economics*, p. 106.

was doing before the war — spin faster and faster to maintain its equilibrium.[11]

This fact becomes even more patent when one considers that industrial processes concern themselves with goods of a material kind. Commodities must needs be fabricated, moved, assembled, and ultimately sold. Such processes are of a kind that place a singular emphasis on action, physical and mechanical; action, moreover, that is kept alive by the sustaining flow of scientific discovery and invention. Industry pivots on action as philosophy on knowledge, imagination, and thought. Indeed, the machine has recently been defined as "action particularized into a body."

What has been said of the industrial machine as a whole must of necessity affect the people connected with it. If industrialism is driving onward at a reckless pace, man is moving along with it. In the factory the effort expresses itself in the ideal of full utilization of plant and the utmost economization of time. The actual job of speeding up production may take the form of secret bonuses and premiums, piece rates, and efficiency payments.[12] So far as office workers and business executives are concerned, there is the modern office with its armament of up-to-date devices to further the ends of quick disposal of office routine and keen, successful prowess in the fields of advertising, speculation, finance, and salesmanship.

Such developments help to explain the inordinate importance of quick transportation and communication in our economic

[11] Another factor creating a necessity for a rapid rate of industrial growth, according to Foster and Catchings, is the deficit of consumers' purchasing power. The automobile industry, they argue, protected the people of the United States from the ill effects of such a deficit. Accordingly, "the present prosperity of the United States cannot be sustained unless some other industry or combination of industries develops as rapidly in the near future as the automobile industry has developed in the recent past." — *World's Work*, Dec., 1926, p. 174.

[12] Lewis A. De Blois states that unsafe overspeed may be the result of a variety of factors, among them the following: pressure by management to increase production, piece-work rates, bonus for production above normal, and effort to maintain previous rates despite changes in operating conditions and depreciation of operating equipment. See his *Industrial Safety Organization for Executive and Engineer*, p. 224.

order. "The biggest cost savings of today and tomorrow," writes an eminent engineering authority, "are likely to come from moving rather than from making. This is the decade of mechanical transportation."[13] There is little doubt of this in the light of the advantages of economization in capital and interest, quick goods turnover, and smaller inventories.[14] And moving applies not only to railroads, vessels, motor trucks, aëroplanes, and other equipment for carrying goods, but also to telephone, telegraph, and radio, which carry words, transmit thought, and accelerate the circulation of sentiments, opinions, and facts.

It is evident that a variety of influences playing on modern man accounts for the preëminence of the speed phenomenon. In this country, immigration, too, has left its mark. A new world with illimitable resources offered the earlier arrivals enviable opportunities for successful enterprise. The alien multitude, crowding into American ports, provided the indispensable accessory for profitable industry, cheap and abundant labor. The immigrant was here to feed industry with life, as fuel feeds the engine, and drawing unstintedly from this source, a far-sweeping intensification of the pace of economic development resulted.

It would seem that the matter has worked out somewhat in circular fashion, making it difficult to distinguish cause from effect. Immigration, conjoined with the modern industrial metamorphosis, has given us giant cities, where noise, speed, and business "pep" come to a focus. But these areas by the strain and agitation of their confused life have precipitated new elements of instability and distraction. Whether looked at from the point of view of seething thoroughfares, crowding factories, the contrasts of luxury and squalor, the lust for sensation, or the massing together in narrow compass of hordes of people with no local attachments, the city seems the very incarnation of the modern spirit of haste, restlessness, and strain.

[13] J. H. Van Deventer, "Ford Principles and Practice at River Rouge," *Industrial Management*, October, 1922, p. 196.

[14] A speeding-up of freight service to reduce the cycle of manufacture from 22 to 14 days during the depression of 1920–21 resulted in a saving to the Ford Motor Co. of interest on $28,000,000. See Ford and Crowther, *My Life and Work*, p. 175.

Perhaps of equal importance with any of the facts heretofore considered is the pecuniary profit-making motive, universally operative in the economic order, a motive centering about the ideal of competition, self-help, and economic success. The pecuniary bias is emulative, as Veblen would say. This system, moreover, attains its best form in the setting of democratic institutions which give due recognition to contract, property rights, and personal liberty, and which in the new American environment obliterate the lines between classes. Brought to a head in this country, such conditions seem ideally fit to bring competition to its highest pitch; to place the utility of exertion, "punch," and strenuousness in the foreground; to glorify action.[15]

But the relentless urge of competition expresses itself outwardly in the effort to acquire wealth. And the method used is the old one of pressing and crowding, for a slight differential advantage may give the prize.[16] An editorial in a recent number of *Industrial Digest* speaks of "extravagant and often futile attempts to force extra rapid growth for an individual concern at the expense of competing houses." It proceeds with this bit of suggestive comment: "But there is really a lot of selling that is done to satisfy pride or keep up to an artificial sales quota based on so much above last year, that is not justified by the

[15] The following comment by Veblen is of interest in this regard: "Probably, also, no class of men have ever bent more unremittingly to their work than the modern business community. . . . The business community is hard at work. . . . This tension of work is felt to be very meritorious in all modern communities, somewhat in proportion as they are modern; as is necessarily the case in any work that is substantially of an emulative character." — *The Instinct of Workmanship*, pp. 226–227.

[16] The way this works out in the ladies' garment industry through the pernicious jobbing sub-manufacturing system is well explained in these words: "The jobber is interested in having as many sub-manufacturers as possible who would compete with one another for the bundle. The keener the competition, the cheaper he gets his work made up. For this purpose he concentrates the production of all his work in the shortest possible time and usually in the slack season, since then the sub-manufacturers will be eager to get the bundles and will produce it cheaper." The effect on the worker is to rush the life out of him during the season, to give him less work during the year, to undermine his morale, and to cause the weaker individual to violate union rules. See "An Abnormal Industry," by Morris Sigman, in *Justice* for Nov. 11, 1927, p. 5.

results on the balance sheet at the end of the year." Indeed, it would appear from the endless reports of production and sales records broken that such concerns cannot relax even if they would. They actually do seem to spin faster and faster in order to maintain their equilibrium.

There is also the bearing of population on this problem. It took approximately a century to duplicate the population record of half a million years. In 1830 the population of the world was about 850,000,000. At present it is considerably more than 1,700,000,000. The world population, according to East, is rising at the most rapid rate in history.[17] The inordinate increase in the population of such countries as the United States, England, Germany, and Japan, means an enormous load of life piled on the shoulders of industry. It is evident that the momentum of business cannot be unrelated to the overwhelming problem of enabling these scores of millions of people not only to live but to live decently. There must be no let-down, if such let-down bring the specter of unemployment a measurable distance nearer. On the contrary, there must be a continuous, onward movement of producing and selling. Respite may come as the consequence of cyclical readjustments in the wake of excessive buying, speculation, and expansion, but not as a guest making his appearance by friendly invitation.

Thus far the influence of unfair methods on the business pace has not been considered. Yet in the light of the ramifying operations of those who refuse to observe the rules of the game, this influence should not be underestimated. Its bearing in individual cases is to induce the entrepreneurs who stand to lose through the ruthless practices of competitors to exert themselves to the utmost.[18]

One must remember also in this connection that the world of business is a free-for-all. There are no formal educational or

[17] Edward M. East, *Mankind at the Crossroads*, p. 75.

[18] Professor Harold L. Reed points out that smallness of size is a disadvantage to those who wish to secure governmental and railroad favors, engage in libelous advertising or make a good showing of unfair practices. On the other hand, "Many expansion projects are influenced by the fear that, if the enterprise fails to grow, it will remain one of the fold later to be pounced upon and destroyed by a rapacious wolf of industry." — *Corporation Finance*, p. 275.

technical requirements that must be met as in preparing for a profession. The quieting influences of selection are absent, but the commonplace incentives of pecuniary gain and success make themselves felt with full force. If, therefore, the tactics of the shrewd, the strong, and the unscrupulous bring the largest rewards, these tactics will not go begging for want of devoted followers.

The preceding considerations suggest the fact that the progress of technology has invested civilized man with a new environment, implying a new order of habit which pivots largely on the actualization of speed. The spatial world through miscellaneous devices has contracted to a fraction of what it has been to our forebears through untold generations. We have became accustomed to learn of events in Germany, China, or Brazil on the day they occur. We read in the evening press the words spoken by an English statesman in Parliament the morning of the same day. In a few scheduled hours, we reach a rendezvous for business, conference, or recreation, hundreds of miles away. We glory in action, directing our efforts primarily to the attainment of quick, positive, and tangible results. We cherish this order of existence as the embodiment of the ideal of progress and the consummation of the good life.

This situation is particularly significant in view of the fact that while there has been in the short space of a century an incredible speeding-up of technological improvement with all the accompanying results, there has been for some scores of thousands of years no recognized evolution of the intellectual faculties. The discrepancy is of more than passing interest, for there is placed squarely before man the challenge of adjusting his conduct to the amazing complexities of the present day with no greater endowment of mental power than he had at the dawn of history.[19] True, there is the heritage of culture, but signs are not wanting that the cultural

[19] It is interesting to note that Mr. Waldo Frank explains the tremendous vogue of the automobile by its usefulness as a means of physical escape. People desire to feel themselves "on the go," to enjoy the sensation of flight, to feel that they are covering ground and getting somewhere, although that "somewhere" be of no intrinsic importance. All this, he asserts, is characteristic of morbid rationalization. See "The Drug On The Market," *The New Republic*, Jan. 5, 1927, p. 194.

resources of civilized society are not always adequate to cope with the elemental impulses of man in the armor of his material equipment. Indeed, one is hard put to it to decide what modifications of social organization would best fit the new order.

Though the full bearing of speed on industrial accidents remains to be cleared up, a number of significant statements on this problem have appeared within the last two or three years. Mr. Ethelbert Stewart, U. S. commissioner of labor statistics, expresses himself in these words: "There is a general speeding-up of workers, both skilled and unskilled, a production per man hour increase which registers a greater number of accidents. . . ."[20] Mr. Stewart has also called attention to two other facts: that modern speed-up methods are particularly dangerous to young workers, and that accidents have increased in small plants. The latter situation he explains by "the tendency to push production to the highest possible point by means of improved machinery, new mechanical appliances, conveyors, power hoists, power trucks, and by speeding up the workers."[21] With regard to these new devices, the smaller plants are at a disadvantage because they are backward in providing safety equipment. Mr. Lewis A. De Blois, a former president of the National Safety Council, writes: "Industry is rapidly becoming mechanical and with mechanical production and mass production the hazards become intrinsically more severe."[22] A prominent automotive engineer tells of a plant where an effort to increase production 30 per cent "with little more than a nominal increase in the number of its operatives" resulted in an increase in the number of accidents of nearly 100 per cent.[23] An interesting sidelight on the problem is offered in the following experience of a

[20] *American Labor Legislation Review*, June, 1926, p. 162.

[21] *Monthly Labor Review*, January, 1928, p. 67. The same writer points out that in the coal mines, where there has been an increase in labor productivity, the deaths per million tons of coal produced rose 10.6 per cent from 1916 to 1924. The percentage increase per million hours of human exposure, however, was 21.4 for the same period, a figure more than 100 per cent greater than the first one cited.

[22] *American Labor Legislation Review*, Jan., 1928, p. 67. See also the discussion of this subject by the same writer in his volume on *Industrial Safety Organization for Executive and Engineer*, pp. 22–24.

[23] *Proceedings of the National Safety Council*, 1923, p. 175.

Ford worker: "In the desire to keep up the speed of production, it appears that most foremen have the bad habit of passing the buck when a machine is faulty, and leaving it to the next shift to have it repaired. It happens now and then that a man is severely injured before the machine is finally halted for the necessary repairs. Such a case happened recently."[24]

It is conceivable, of course, that better motions, equipment, and methods might enable workers to produce more without an accompanying change of speed. Yet it is to be doubted if, in the main, matters work out that way. If the system, as a whole, is tuned up to a high pitch of performance, can the worker escape the new pressure? Will not competitive necessity soon wipe out the margin of unutilized or partially utilized time? Moreover, with a large body of unemployed clamoring for jobs, there is likely to be less regard for beneficent policies, and greater disposition to get more and more out of the worker, or to exhaust his strength and then cast him off. It is commonly pointed out that industry prefers youthful workers and shuns applicants for jobs who have passed the age of forty or forty-five. Theoretically the result of concentration on time-saving is to bring production to the point necessary to yield the highest net economization of time, for one must make allowance for the effects of overspeed on fatigue, absenteeism, accidents, and turnover. But even such net economization may set a harassing pace for workers who are short of the standard, and it is hardly to be expected that all establishments, large and small, will trim their methods to the exigencies of broad-gauged scientific understanding.

The problems raised by the "new speed" are sufficiently grave to justify our taking stock of the situation. Glib utterances that seek to tell the story purely in terms of production, prosperity, and profit clearly distort the picture. No phase of life is immune to the influence wielded by the modern "spirit of crowding," and if the good results are in evidence, the evil is none the less to be recognized. The solution no one can make bold to forecast.

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[24] *Ford Man*, Nov. 17, 1919.

BUD FLAT AS A TYPE AREA OF THE RIVER FLATS ON THE CUMBERLAND

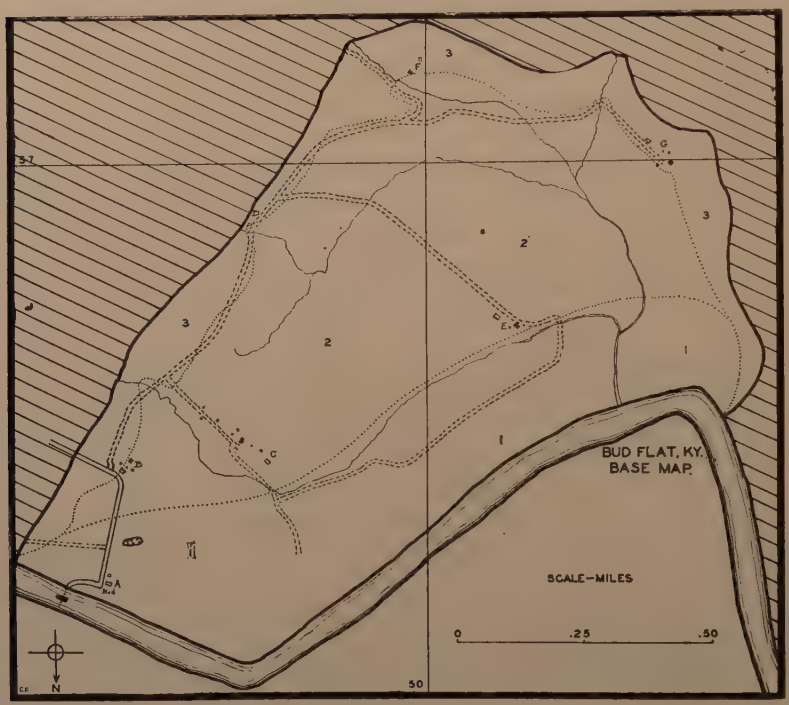
CHARLES V. V. CRITTENDEN

THE Cumberland River, the central drainage unit for this area, presents a placid picture during most of the year. Moderately large, with water opaque from brown suspended material, it gives the impression of flowing by at about the same ambling pace that the natives use in walking about. And yet on examination it proves that it has latent powers for work and fury. During late winter and early spring freshets, it rises to terrifying heights, inundating large parts of the river flats and doing much damage. The river is now in the early mature stage of incised meanders with typical features, always sharply undercutting on the outside and downstream side of its meanders and gently depositing a river flat behind it on the slip-off side of the spurs. Thus the valley through this area gives the general impression of being fairly steep-sided with a moderately wide level bottom; the river meanders from side to side, so that the bottom has the appearance of isolated scroll-shaped flats between which there is no easy land communication. There is one complication — the river at present is distinctly underfit. There are usually two fairly distinct river levels with their own features.

Some notion of the general features of Bud Flat may be gained from an inspection of the U. S. G. S. map (Monticello, Kentucky, Quadrangle) and the two detail maps: the base map and the relief map (Maps 2–3). On all sides, except the river side, the Flat is surrounded by steep-sided slopes, beyond which is the surrounding upland. These slopes are concave, not graded by soil creep, and at the bottom have an outflaring skirt — the colluvial base which slopes off gently to the flat bottom. The dotted line (on the base map) which encloses the area number 3 is approximately the

boundary of this feature. The soils are exactly what the name implies, a scrambled mass of fine and coarse material, the offscourings from the steep slopes above.

The Flat itself has two distinct levels, marked 1 and 2 on the

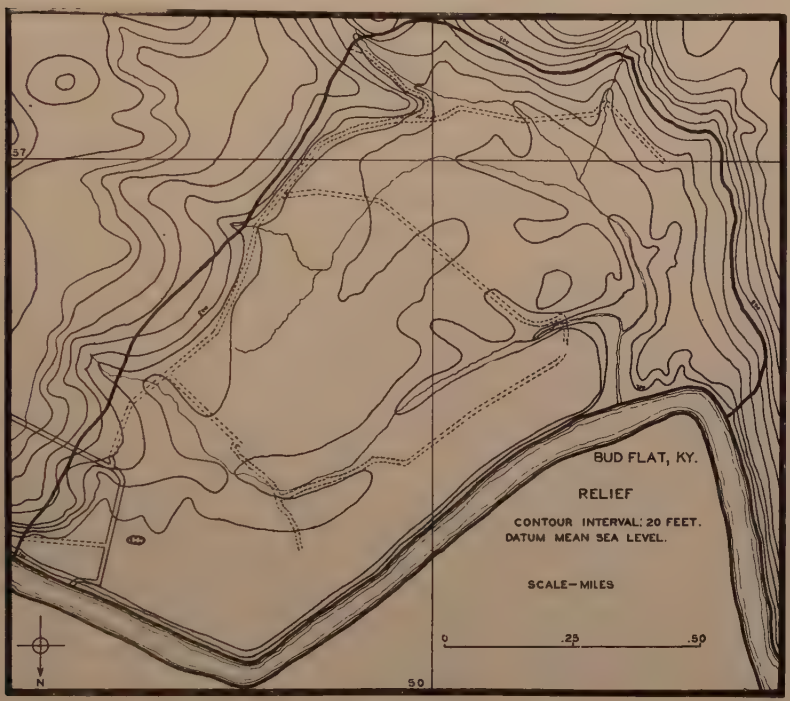


MAP 2

base map. The upper and older (2) level was made at a time when the river was larger and more active. The soils here are sedimentary, but of quite coarse nature. Chert pebbles, the size of a man's thumb nail and larger, are mixed in with a coarse clay loam. The features of natural levee and back-marsh are only very indistinct. They have been about obliterated by surface erosion subsequently to the lowering of the river, and the back-marsh has tended to become filled in by the spreading out of the colluvial base.

It is on the more recent lower (1) level that sharper features

appear. The bank of the river rises abruptly to a natural levee and slopes very gently back to the number 2 bottom. This would be back-marsh except for the rather complete drainage-system which has cut itself into the soft alluvium of both levels. The soils



MAP 3

on this level are much finer. Fine sands are only partially held together by a small fine clay content.

There is a quite complete and rapid drainage-system for the Flat as a whole. Only in one place just south of the Bud store is the number 1 back-marsh poorly drained. Most of the streams arise in sharp V-shaped gullies which are cutting back into the highland around the Flat. The easternmost stream flows across the upper level and then follows the lower level back-marsh, paralleling the river before joining the other stream and discharging into it

over a miniature delta. This is very characteristic of tributaries in maturity. By inspection of the relief and land-use maps, some notion may be gained of the degree to which the two main streams have cut pronounced gullies in the Flat in their effort to reach down to their base level.

So far as can be ascertained, the natural vegetation always tended to be woods, mostly hardwood, but the land has long been cleared by man because of its relatively much higher value for agriculture than the land of surrounding areas. Of wild animal life there is consequently very little left.

Historically, Bud Flat has had a rather prosaic development. Its present name was bestowed upon it by the United States Postal authorities — a simple unmistakable name, not likely to be duplicated. But, to go back to the first real inhabitants, there is ample evidence of Indian occupation before the arrival of whites. On several low knolls on the number 2 level are remnants of what must have been Indian work-camps. Scattered flint stones, not naturally appearing in the soil, most of them worked chips, or partially finished or defective arrowheads and spearheads, are found scattered about in profusion. On a shelf in the steep slope to the south of Bud Flat was found a small mound, which, after laborious efforts on the part of an archaeologist, yielded a few specimens of broken pottery and charcoal at several levels. Undoubtedly it had been a ceremonial mound. The Indian has now almost entirely disappeared from this and surrounding areas.

After a careful effort to sift out what seemed to me to be doubtful embellishments, I offer the following as the history of the Conley family which now occupies the dominant position in the Flat. The great grandfather of the present middle-aged generation was the son of early migrants through the Appalachians. When he was still a boy, his father's place was raided by Indians, his mother was killed, his father driven away, and he himself taken captive. He lived with them until about the age of nineteen when he became dissatisfied and quit the Indian life. A year or so later he married the daughter of a white settler and acquired and began to clear up some land on Bud Flat. He prospered moderately and his sons a little better, the family gradually clearing up new land

or acquiring land from less successful neighbors until the present Conleys occupy at least all of the better land of the Flat. Four of the seven families in the Flat and twenty of the twenty-nine present inhabitants are Conleys. The Conley farmsteads are marked *C*, *E*, and *G* on the base map, and the house and store marked *A* belong to one of the younger Conleys, who, having been injured in the World War, now manages the store and occupies quite an influential position with the people of the Flat and with the hill people from the north side of the river.

The one real intruder on the Flat occupies the farmstead marked *B*. He seems to have been a man of continual financial ups and downs who, finding himself up and one of the Conleys in financial difficulties, managed to purchase a moderate holding on the Flat. His chief occupation at present is speculation in hogs, buying them from outside, and fattening them on his corn and hillside pastures, and then selling them to the outside market. The present season seems to have cut down his profit considerably as a falling market caught him with several batches of hogs which he had purchased at a rather high price.

The house marked *D* is occupied by an elderly negro and his son and daughter-in-law. The son finds employment outside the Flat, while the old negro is a kind of tenant-retainer of the Conleys who works for meager shares in their farm produce. The farmstead marked *F* is occupied by an old man, his wife and daughter, who eke out a barely self-sufficient existence with one cow, a few chickens, and a hillside corn and vegetable patch. They really do not count as Flat dwellers, but are almost entirely characteristic of the average hill-dweller outside the flats.

The dwellings of these people, except for the one last mentioned and the negro tenant's house, are remarkably modern and well kept for this part of Kentucky. Painted on the outside and plastered on the inside, they form a sharp contrast to the hill people's homes. The furnishings, while not attractive, are complete. Around many houses there has been a definite effort to make the immediate yard somewhat attractive with grass and trees, and often the well or pump-house looks cheerful rather than ugly. During the middle part of the hot summer days the farmer and his

family are often seen sitting in the shade in his dooryard, entertaining a neighbor who has strolled in. Even some of the smaller outbuildings near the houses have been cleaned up, but most of the outbuildings and all the barns are left unpainted although not unrepaired. The barns are of moderate size, with sharp, peaked roof, a small hay-mow above, and animal stalls and implement storage below. There are almost always several smaller buildings; one a combination work and junk storage shop; another a corn-crib; a small chicken coop; and farthest away, the pig shelters in which the general rule is to give only that amount of floor space which will allow the pigs to get crowded accommodations.

A word or two might be interesting concerning the store, a plain, dirty, poorly kept rectangular building set above the surface of the number 1 natural levee on piles to keep it out of the way of an ordinary spring flood. Nearly all other buildings are on the number 2 level to avoid the floods, but the store must be handy for the hill people across the river, and the owner lives next to it except in flood time. The interior of the store is a great mess: shoes and soap; groceries and sewing materials; boxes and rough counters; pop bottles and sacks of grain and flour. The completeness of the stock is astonishing if one can afford the time for observation. Business is transacted in the most leisurely manner. After the leisurely transaction, one is required by convention to stand around on the front steps and scatter any wrappings or containers that his merchandise may have been packed in, while he chats with other visitors to the store.

As the land around Bud Flat became settled and oil was discovered around Monticello, it was found that the easiest access to the river, the only good connection with outside areas, was the descent down the east slope of the Flat. Thus Bud became an important boat landing, and goods, both outgoing and incoming, were transshipped and temporarily stored here. The mails came by boat for distribution in the hinterland. But this has changed now. The Monticello-Burnside pike is passable through to the railroad at Burnside, which furnishes faster transportation. Bud Flat has very little contact with its surrounding country now, except that

the mail comes down from Mill Springs. Commercially Bud still uses the river as its communication line. Young Conley at the store has a one-cylinder flatboat which takes out and brings in merchandise and supplies at the rapid rate of three or four miles an hour. Occasionally one of the puffing, stern-wheel steamers stops to take on or discharge a load of pigs from flatboats, which they always push instead of tow. It is most amusing to sit on the bank of the river in the northwest corner of the Flat, where one of the sharpest bends in the Cumberland occurs, and watch these steamers with one or two flatboats maneuver to make the bend. They back, go forward, puff and snort, ram the bank occasionally, members of the crew run about cussing, and there is a general flurry until the trick is turned and the boat settles down to its loafing pace up or down stream.

There is only one automobile owned on the Flat and that is seldom used. The appearance of a car causes somewhat of a stir because it is only an occasional bold or reckless driver who attempts the road down from above or has any business in the Flat anyway. Buggies are seldom used. If you are going somewhere and do not care to walk, you ride a horse or perhaps take the team and family wagon.

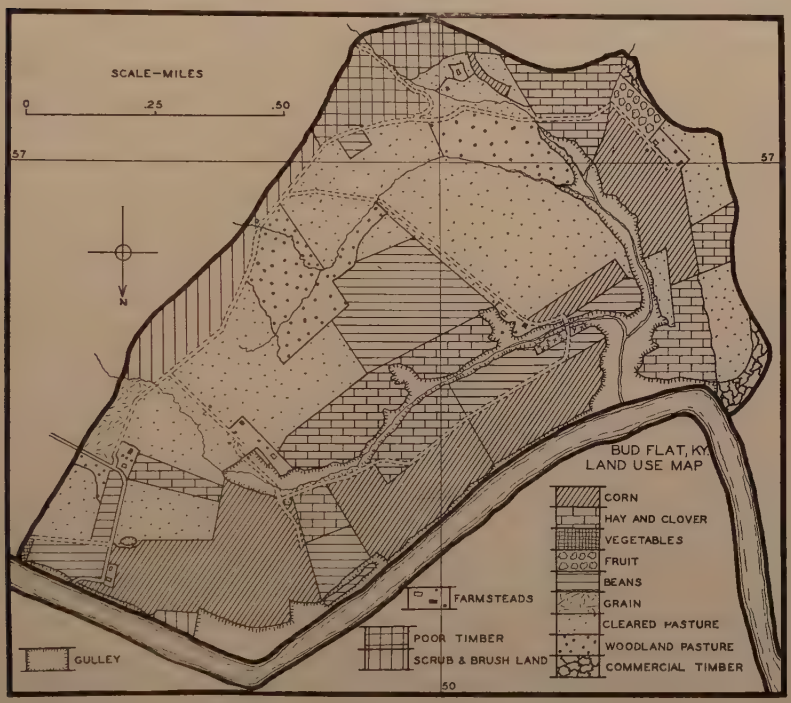
During the winter, logs are hauled down from the highland country to the top of the natural levee, to be rolled down to the river and hauled away by flatboats in the spring. This process is notoriously hard on the one road down to the Flat, as it chews up the surface of the road on the steep slopes and water erosion quickly changes the road to a gully. Very little effort seems to be made to correct this — it is hardly worth while for the small amount of traffic.

STATISTICS TAKEN FROM PLANIMETER READINGS ON LAND-USE MAP

1 square mile	3.626	Area Bud Flat	3.555
Land cleared for agriculture			76.9%
Land directly in use for animal industry			73.7%
Land not directly in use for animal industry			6.3%
Land not cleared			23.1%
Commercial timber	.04	1.2%	
Woodland pasture	.21	5.9%	
Poor timber	.14	3.9%	23.1%
Scrub and brush land	.13	3.6%	
Gully	.30	8.5%	
Fruit	.0175		
Grain	.03		1.1%
Vegetables	.002		
Corn	.70		20.0%
Beans	.316		8.9%
Cleared pasture	1.05		30.0%
Hay and clover	.44		12.9%
Roads, farmsteads, etc.	.14		4.0%
			100.0%

Thus we have an isolated area, isolated both from the upland and neighboring flats except by river. Conditions are such that the one occupation of the inhabitants must be agriculture. The soils are comparatively good and 76.9 per cent of the land is cleared. Practically all agricultural operations center around the animal industry because of the relative ease of transportation out to distant markets, and the greater value in the centers of population. The number 1 level is best suited for the raising of corn and beans because of ease of cultivation and they grow well here. Their dominance on this level is easily seen on the land-use map (Map 4). There is rotation of crops after a fashion, but none of that well-timed, carefully planned rotation which one finds in the corn belt. The corn and bean fields always look well cared for, and yet the farmer never exerts himself to keep them so. He works only during the cooler parts of the day, or on an occasional cloudy day. His two periods of greatest exertion come during haying time and when the spring floods wash out the fields which have already been seeded, which happens only occasionally.

Hay, usually in the form of seeded clover, is planted around the edges of the gullies or on the steeper slopes of the colluvial base where soil and surface conditions are not good for more intensive working. The yield is almost always quite heavy. It is partially stored in barn lofts, but mostly in round stacks with conical tops



Map 4

to shed the rain. There is almost never enough snow to keep animals from getting at it during the winter.

It is on the number 2 level and the colluvial base that the domestic animal industry proper appears. The number 2 level is dominantly cleared pasture with woodland pasture where the surface is rough. Here are pastured cattle primarily, with mules and horses for work purposes. The distinction between a work and a riding horse is never sharply drawn. The number 2 level then

has only a few corn and bean fields on particularly flat advantageous locations and even then cannot compete with the lower level in production. The colluvial base is not much used for cultivation, but is mostly utilized for pasture, or left in poor timber with here and there a clearing used for hay or pasture. Hogs are allowed to run on the steep slopes and the surface of the ground is often littered with corn-cobs from the corn-fattening process.

What timber appears at all is second growth and never cared for as a wood lot. It is only on the upper part of the western edge of the colluvial base that there appear protrusions of the commercial timber which lies on the steep sides above.

The gullies of the two main streams and the abrupt river side slope of the number 1 natural level furnish a distinctly different landscape from the rest of the Flat. Steep slippery slopes are covered with a profusion of natural vegetation. Cane and brambles are so thick as to be almost impassable without the aid of an axe. The whole entanglement is heavily shaded by trees, usually maples, so that the ground seldom dries out and footing is precarious. Domestic animals steer shy of such places. About the only use to which this land has ever been put has been the harvesting of sorghum cane, which, originally planted, now grows wild. In the northwest part of the Flat next to the gully may be seen a small field indicated by the symbol ×××. These are upright posts about four feet high on which are nailed horizontal crosses. Around these the harvested cane from the gullies is stacked in shock-like piles and left till winter when it is used as fodder, particularly for mules.

On the number 1 level scattered here and there in the cornfields may be found little vegetable and melon patches. They grow well and were Bud near an urban area the whole level would undoubtedly be used for vegetables — but there is no market for them. Fruit is almost entirely lacking. In addition to the few trees in the immediate yards of the farmsteads there is only one dilapidated orchard in the southwestern colluvial base. Grain is very seldom raised, for it has been found not to yield well and there is only a very meager local demand for it.

Bud Flat, one of the many flats in the Cumberland River Valley through this part of Kentucky, is an agricultural area and un-

doubtedly will remain so. Crops are grown mainly for food for animals, which is never an intensive type of agriculture. Because of its isolated location and slow commercial connections with outside markets, it will remain as it is until population pressure in the country as a whole demands that such areas be more intensively utilized. Life is easy-going and in comparison with that of their neighbors, quite prosperous. It would take the sudden discovery of valuable resources, such as minerals, to change the character of the life and the people and make this a land of hurry such as we find in the middle-western Great Lakes area. There are often rumors among the natives of proposed great water-power developments in the Cumberland River, but I think a thoughtful study of the country will convince one that this is destined to remain in much the same easy-going state of development that has been gradually brought about by the westward expansion of white settlers.

University of Michigan

THE ISLAND OF GONAVE: A STUDY IN KARST LANDSCAPE

ROBERT BURNETT HALL

THE island of Gonave, which has an area of some 300 square miles, is the largest of the outlying possessions of the Republic of Haiti. It lies midway between the two great peninsulas of the mainland in the Gulf of Gonave. Its population does not total more than 10,000, as compared with the island of Martinique, which has about the same area but supports a population which is nearly twenty times greater. Three factors are primarily responsible for the sparse settlement of Gonave. These are inaccessibility, historical background and paucity of water.

INACCESSIBILITY

The extreme inaccessibility of Gonave is due in part to its isolation and in part to the uninviting nature of its coasts. The island is not touched by the main agents of world commerce and must depend upon the irregular trips of small fishing and trading craft from the mainland. The coasts, for the most part, are fringed by an almost impenetrable mangrove barrier, which gives way to sterile saline flats and rocky hills covered with thorn forest (Pl. XV, Fig. 1). Mosquitoes, sand flies and giant chiggers occur in great numbers at different seasons. Offshore reefs and shallow waters make approach by large vessels impossible. In places, sea-cliffs, backed by steep and rocky slopes, occupy the coast.

HISTORICAL BACKGROUND

Partially as a result of its inaccessibility and partially owing to certain unfavorable aspects of the interior, the history of Gonave has differed from that of the main island.

It appears that there was little if any Indian occupation of the

island in pre-Columbian days. No artifacts of their culture have been found to date. Probably the island has been worked in more detail in this respect than any part of the mainland. The present military governor, Lt. F. E. Wirkus, who has located numerous sites upon the main island, has failed to find any trace upon Gonave during four years of diligent searching. However, as a result of the murder of the Indian Queen Anacoana by the Spaniards, in 1504, many of her followers are said to have fled to Gonave from the mainland.[1] The Spaniards left the island unmolested and it would be safe to surmise, without documentary proof, that the Indians took refuge here as they did in other places the white man did not want. On the main island they hid in the high mountains and on the small island in Lake Enriquilo.

During the later Spanish and all through the French occupation, the population was increased by a second group of refugees. These were the "maroon" or runaway negro slaves. This would have included many persons who had been little affected by European contact. As we shall attempt to show, in another paper, the culture of the present-day population is even more dominantly African on the island of Gonave than it is on the mainland. How little the island was known in the days of the French Colony is shown by the fact that the otherwise well-informed Moreau de St. Mery[2] makes but one short and erroneous reference to it in his entire work on the colony.

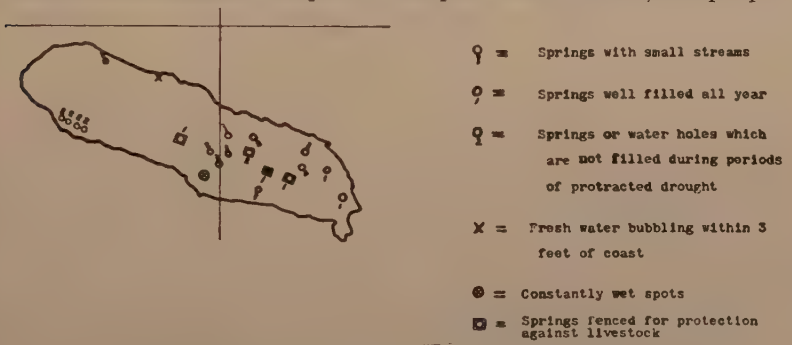
After the establishment of the Republic, Gonave became the football of Haitian politicians. It has been let out from time to time on concession. The chief interest, at first, was the exploitation of the timber in the interior sections. When this was gone the peasant farmers were made to furnish revenue. Taxation has been exorbitant and the agents sent by the concessionaires have made the burden still heavier by petty grafts. Partially as a result of this situation, there has grown up a group of semisecret, coöpera-

[1] Ardouin, B., *Géographie de l'Ile d'Haïti* (Port au Prince, Eds. 1832, 1856 and 1864), p. 26; Fortunat, Dantès, *Nouvelle Géographie de l'Ile d'Haïti* (Port au Prince, 1888), p. 408.

[2] Moreau de St. Mery, M. L. E., *Description topographique, civile, politique et historique de la partie française de l'isle Saint-Domingue* (Philadelphia, 1787–1798), Vol. II, p. 527 f.

tive, agricultural societies called the Société Congo. These organizations have found methods of combating the worst aspects of this exploitation.

Many of the present-day inhabitants have come to the island as refugees from the law of the mainland. Others came as wandering fisher folk and have settled down to a sedentary life where land is free and abundant. In recent years, there has been a steady immigration of landless peasants from the mainland. These have settled, for the most part, on that part of Gonave which lies nearest their former homes. In spite of the political situation, the people


= Springs with small streams
= Springs well filled all year
= Springs or water holes which are not filled during periods of protracted drought
X = Fresh water bubbling within 3 feet of coast
= Constantly wet spots
= Springs fenced for protection against livestock

Map 5. Island of Gonave, showing water sources

of the interior part of Gonave experience a higher standard of living than the average for rural dwellers on the main island. There, holdings are larger and there is a greater spirit of progress. The island of Gonave is Haiti's frontier.

WATER RESOURCES

The lack of water on Gonave is due to the low and erratic rainfall, rapid evaporation and the porous limestone strata which form the surface rock of the island. The average annual rainfall at the coast is estimated at about 25 inches and in the high interior at possibly 40 inches [3] (probably Koeppen's *Awi* type of climate). The departure from the average, in any one year, may equal the average figure. It is said that in the year of 1923 no rainfall occurred. In other years, the average is greatly exceeded.

[3] Koeppen, W., *Die Klimate der Erde.* Leipzig & Berlin, 1925.

The surface forms of Gonave are those of a karst country. Different portions of the island are in different stages of karst development. There are no through-flowing surface streams and there is only an occasional surface exposure of a karst stream in rainy weather. There are but two or three springs which carry water all the year. A half-dozen small springs carry water part of the year. An equal number of large water-holes have water in them during the greater part of normal years. At two points near the shore, fresh water bubbles up in the sea. These sources constitute the only supplies of water for domestic use and stock watering (Map 5).

GEOGNOSY AND LAND FORMS

The island of Gonave is an asymmetric anticline, the crest of which plunges in both directions from its apex,[4] the Morne Chein Content. A radial system of solution valleys can be identified, conforming to the main structure of the island. The surface rock is of porous limestone throughout and the land forms of the island are all of karst types, except at the sea's edge.

Three types of land surface can be recognized. The distribution of these types corresponds with the three landscape types of the island. The names for the divisions used here are taken from place names on the island about which the particular landscape type in question is characteristically developed.

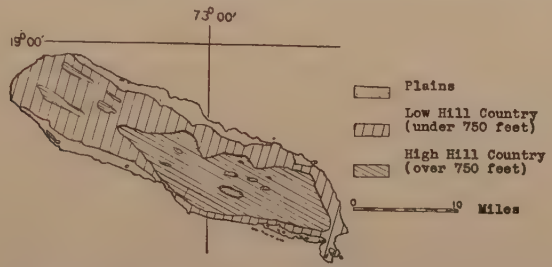
THE PLAINE MAPOUX

This type is confined to the vicinity about the apex of the anticlinal crest. It is the most elevated area on the island (Map 6) and, in consequence, receives the heaviest rainfall. Here the greatest amount of strain took place, resulting in more intimate and better developed fractures; also the bottom of the soluble limestones is highest above sea-level. As a result the development of land and drainage forms has been the most rapid. This area is now in the late mature stage of karst development.[5] In valley and

[4] Woodring, Brown, Burbank, *The Geology of the Republic of Haiti* (Port au Prince, 1924), p. 418.

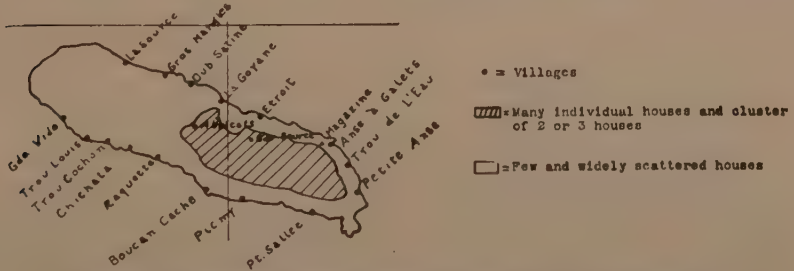
[5] Cvijić, Jovan, "Hydrographie souterraine et évolution morphologique du Karst," *Recueil des Travaux de l'Institut de Géographie Alpine* (Grenoble, 1918), Vol. 6, pp. 375–426.

sink bottoms the underlying insoluble metamorphic rock is but thinly covered with rubble and soil. In at least two places it is completely exposed. Solution features can no longer deepen and karst forms are in the process of decadence. A number of large uvalas are found. The Mapoux Plain is the largest feature of this



MAP 6. Island of Gonave, showing land surface

type on the island and also the most elevated (1800 feet). Its encircling limestone walls rise seven to eight hundred feet above the floor. The floor slopes gradually from the sides toward the center and is covered with a thin layer of coarse, reddish soil material. The lowest or middle portion is permanently in swamp. Tempo-



MAP 7. Island of Gonave, showing distribution of population

rary springs occur along the edges of the uvalas and in the solution valleys and larger sinks. The two larger permanent springs of the island occur in this district, as do the more important water-holes (Pl. XV, Fig. 2).

This division is the most populated and productive on the island (Map 7). The amount of water available, everywhere on the

island, determines the distribution and the density of population. In this area more ground water is available than elsewhere and also the rainfall is the greatest. The largest sinks are found here with their flat bottoms of moist, deep, soil material. Dwellings and crop lands occur in concentric circles about the supplies of water, their density becoming less with distance, finally disappearing at about the ten-mile zone. This distance seems to be the maximum of one day's travel. The crops of this area are commonly of types demanding more moisture than the crops found elsewhere on the island. Yams, congo beans, malanga, and castor beans are among the most common crops of the valley floors and sink bottoms. Plantains are grown on the colluvial bases of the limestone cliffs, where a seepage occurs. Plantains and maize occupy the moist ground near the centers of the uvalas.

Habitations in this area are of the permanent type. The walls are plastered and the dwelling unit is composed of three huts. The largest one is for family occupation, a slightly smaller structure, without windows, is the store house, and the third has but three walls and serves as a kitchen.

THE PLATEAUX TYPE

This type lies just below the area discussed above. The major areas are confined to the north and northeast parts of the island. This type may be described as in the early mature stage of karst development. Here the usually dry valleys contain surface streams for a brief period following heavy rains. Uvalas are small and numerous. Many sink holes occur on the intervening uplands and are found in large numbers on the valley floors. They are of the doline type and are filled with reddish sandy and silty material. In fact, the term "mantled" karst is suggested for this kind of country, as is the term "naked" karst for areas with little or no soil cover. The limestones at these lower levels are of Miocene age and are less pure than the Eocene which constitutes the surface rock of the Mapoux Plain district. The impurities remain on the surface as soil material and tend to round off the natural karst lines. Also, the impurities from higher levels lodge here for a

while on their way to the sea. Springs and water-holes are small, scattered, and temporary in nature.

The population of this area is sparse and the land which was once forested is now overgrown with tall grass and brush. Temporary settlement and milpa agriculture are the common forms of occupation. Rainfall is less, so that crops are chiefly of drought-resistant varieties. Cotton, *petit mil* (a non-saccharine grain sorghum) and cassava are the main crops.

Nearer the sea, the rainfall is very low and the porous limestone rock extends below sea-level. The discharge of subterranean streams is not possible in some places. The impure materials from upper levels have in places accumulated to considerable depths. The dolines are small and very shallow. The solution valleys are not deep and their floors are covered with sand and rubble. Small surface streams are numerous during and immediately after periods of rain.

The land is covered, for the most part, with thorn forest and is highly unproductive. A little cotton and *petit mil* are grown in the more favored areas. Goats and very thin hogs are grazed in the thorn forest. Charcoal is made and sold to more favored portions of the island. The supplies of water used are often brought by boat to the nearest point on the coast.

THE ANSE À GALETS TYPE

These are the districts where alluvial deposits have been laid upon the slightly submerged sea bottom fringing the island. A few feet beyond the land's edge a mangrove thicket presents a barrier to approach by sea. In some places, this extends unbroken. In others, where the configuration of the shore-line allows an active wave action, there are openings and small crescentic sand beaches occur. Behind the mangrove, a sterile and desolate saline flat stretches, in places, a quarter of a mile or more to the beginnings of the thorn forest. The first stunted trees of this forest occupy the highly alkaline soils of the inner alluvial plain. This portion is about equal in width to the saline flat and slopes gently seaward.

There are two sites of human occupation occurring in this landscape type. The most common is the crescentic sand beach.

Here squalid fishing villages composed of unplastered wattle huts have been built to take advantage of the opening through the mangrove and the dry sand of the beach. The inhabitants of these sites depend upon the land and the sea for their sustenance. Fishing among the offshore reefs, gathering conch from the shallow sea-floor and oysters from the roots of the mangrove trees, and planting tiny gardens on the upper slopes of the rocky hills behind the village allow them a meager existence. Some few do occasional trading with the mainland and now and then a boat builder's establishment is seen. Fresh water is brought in by boat from distant points on the island and sometimes even from the mainland. The mangrove furnishes shelter for the flat-bottomed fishing boats.

The other type of coastal site occurs just behind the saline flat where conditions are more healthy and where water can be secured for part of the year from water-holes or temporary springs. Most sites of this type are on the side of one of the radial karst valleys, down which the trade from the interior usually comes. These people combine farming with trading. The huts are more commonly plastered than those at the sea's edge, which tells of a more permanent nature of abode.

University of Michigan

PLATE XV

FIG. 1. The mangrove barrier, the saline flat, and the thorn forest of the upper alluvial plain at Anse à Galets

FIG. 2. The spring of Grand Source. Gourds (seen in the foreground) are the universal water-containers of Gonave. They are cut from the trees when large enough to hold approximately one gallon

SOIL TYPE AS A FACTOR IN HIGHWAY CONSTRUCTION IN MICHIGAN

CHARLES E. KELLOGG

HIGHWAY engineers have always recognized that certain soil conditions such as external drainage, land surface, and texture of the surface soil must be considered in subgrade designs. Until recently, however, none have felt the necessity of studying the fundamental characteristics of the soil and their influence upon the construction and durability of highways. Many of our highways are surfaced with gravel, macadam, and similar metals, in which the damage caused by settling, heaving and "frost boils" can be rather easily repaired. With the advent, however, of the hard-surfaced roadways, constituted to meet the demands of tremendous increases in traffic on certain of our main trunk lines and near our large commercial centers, the problem has changed. Engineers find that damaged pavements are not so easily repaired and are often a total loss. With the cost of modern paved highways ranging from $25,000 to $40,000 per mile, or even more in certain places, it is obvious that frequent replacement and repair are costly.

Because of these developments in highway construction engineers have recently begun to realize that a careful consideration of the subgrade material is essential. During the past six years, Terzaghi, workers in the Bureau of Public Roads, and others have proposed various physical "tests" for subgrade soils with the primary object of evaluating soil characteristics that appear to exert an influence on the pavement. A classification of soils has been proposed on the basis of some of these physical tests.[1] Most of these workers have completely ignored the profile character of the soil. If these physical tests are accurate, where in the soil profile

[1] Terzaghi, Charles, "Principles of Final Soil Classification," *Public Roads*, 8 : 341. 1926.

should the samples be taken? Soils have several horizons of widely varying physical character and often, as in the case of Ottawa, Allendale, Ogemaw and other soil series, both extremes in texture — loose, open sand and impervious clay — are represented in the profile. In Figure 8 are illustrated typical profiles of four widely

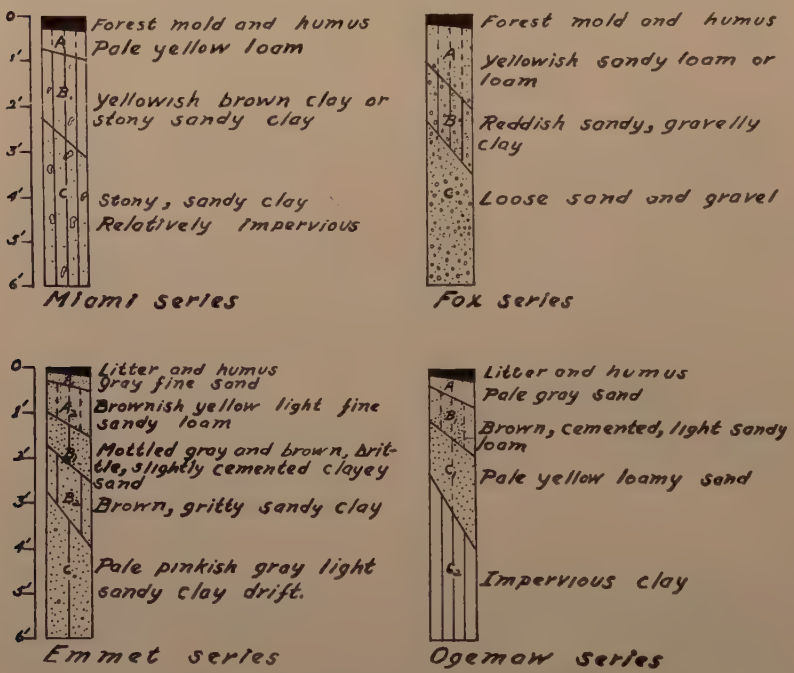


FIG. 8. Typical profiles of four Michigan soils

distributed Michigan soil series. It seems obvious that a soil classification based on any one or two physical characteristics is practically worthless in the study of soils as they exist in their natural condition. Physical tests are very useful in studying the different horizons in each profile and aid us in perfecting the soil classification; but in studying such problems as moisture-holding capacity, shrinkage, expansion due to freezing, and other physical phenomena, we must consider the soil as a whole.

There are three general methods by which we may study the relation between soils and pavements: (1) by studies entirely in the laboratory, the utility of which we have already criticized; (2) by setting up a test road and observing the results, a method that is very costly and gives us data for that particular location only; (3) by a combined field and laboratory method. This last method of attack is being attempted in Michigan by the State Highway Department. It has been used to some extent in Pennsylvania and California, and Rose, of the Bureau of Public Roads, realized its possibilities.[2]

Briefly, the method used in Michigan is as follows: A chaining party of two men marks and numbers stations on the pavement at 100-foot intervals. These numbers correspond with those of the plans for construction. An engineer, familiar with pavement design and construction, maps to scale all cracks and imperfections in the pavement. Using the same station numbers for location, a soil surveyor maps the soil types on a scale of one inch to two hundred feet. The soil types recognized are in accordance with those of the U. S. Bureau of Soils and Chemistry and the Michigan Agricultural Experiment Station; but of course the scale employed allows mapping in greater detail than the regular soil survey for agricultural purposes. Further, the vertical position of the pavement in the natural soil profile is sketched, showing upon which horizon the pavement rests. Several type samples are taken by horizon and sent to the engineering laboratory for mechanical analysis and other laboratory tests. The location where the sample is taken and all observations with regard to the soil and the pavement are carefully noted. In addition, special studies are made at all places where the pavement is damaged and additional samples are collected where some special feature seems to justify it.

It is planned to place the sketch map of the engineer and the soil map on the original construction plans in order that the relationship between the soil, the type of construction, and the condition of the pavement may be studied. The soil horizons will also

[2] Rose, A. C., "The Present Status of Subgrade Studies," *Public Roads* 6:137. 1925.

be sketched on the profile drawings of the plans. The number of cracks, the size of the pieces, and similar data are all tabulated for each location. The laboratory tests give us information in regard to the physical properties of the different horizons and aid in the perfection of the classification.

As a final result it would seem that from these data we shall be able to predict what type of pavement and subgrade construction will be the most satisfactory for the soil type in question. The matter is not quite so simple, however; several factors come into play which profoundly influence the effect of the soil. Some of these are: the area of the water-shed, the horizon of the profile on which the pavement rests, the character of the 'C' horizon below that depth commonly included in the soil profile, the angle of gradient, the height of the water table at different seasons, the snow covering, the depth of the soil above bed-rock, and any other factors which may have an influence on the water relations of the soil. Thus for the same reason that we cannot classify soils without considering all their characteristics, we cannot propose a logical pavement or subgrade design without taking all factors into consideration.

Frost action is by far the most outstanding problem in subgrade studies in Michigan. So far two general types of freezing have been observed: (1) that which occurs suddenly during the freezing and thawing weather of late winter; and (2) freezing which begins in the early winter and steadily increases. It must not be assumed that these are always definite, perfectly separable phenomena, for the two types are probably more often associated than alone.

Little definite information is at hand, but from general observations and some studies of frost heaves we can present what seems to be a logical explanation of the sudden freezing which occurs during late winter and early spring. As the cold weather begins a certain amount of freezing occurs. As the pavement is a better conductor of heat than the shoulders, freezing is deeper under the slab. In late winter we find most of the snow piled up on the shoulders, leaving the pavement exposed. A little warm weather comes, and thawing begins just under the pavement. Ad-

ditional water may also be supplied from melting ice and snow. On the grades the water flows under the pavement and accumulates farther down the slope. As the air temperature falls, the temperature of this pocket of water under the pavement falls quite uniformly and freezes suddenly, heaving and breaking the pavement (Fig. 9). Great damage usually results from this type of freezing. It is now hoped that by the use of lateral drainage structures and the removal of the snow from the shoulders as well as from the pavement, we may be able to correct this condition,

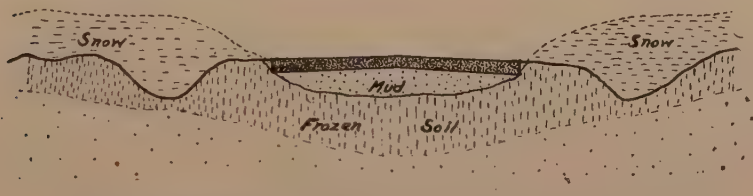


Fig. 9. Cross-section of grade in late winter as thawing begins

but in some places more elaborate drainage provisions must be made than are now being used.

The freezing which occurs throughout the winter is not very well understood. The amount of heaving depends, of course, upon the amount of freezable water present, but, as we have seen already, a great many factors come into play. At first we might assume the pressure exerted to be due simply to expansion of the soil when frozen. By the use of specially constructed apparatus for measuring the volumetric expansion of moist soil upon freezing, the writer has studied the expansion of various soils at different contents of moisture. The results indicate that only a small fraction of the heaving during freezing weather can be accounted for in this way, even with soils completely saturated with water. We know that, no matter how dry the surface soil may be when it freezes, it is invariably wet when it thaws. Furthermore, when weights are placed on the ground before freezing and removed after the ground has frozen we observe crystals of pure ice between the weights and the ground surface. This is especially noticeable in heavy soils.

Bouyoucos[3] has suggested that the ice crystals form in the larger spaces, pulling the water from the small capillaries and causing an upward movement of water which eventually freezes near the surface. The work of Lebedeff[4] and others shows that there is considerable movement of water in the form of vapor, as would be expected where large differences in temperature exist within short distances. It is probable that both forms

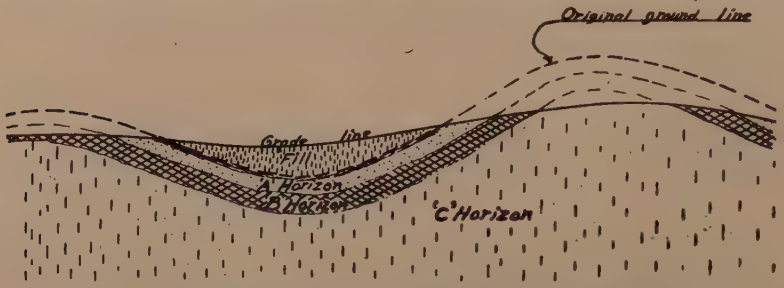


FIG. 10. Longitudinal section of typical grade showing how the pavement crosses the soil horizons in a rolling country

of movement contribute to the accumulation of water near the surface. Some water is probably supplied from the surface, but yet the amount of heaving seems to be quite independent of the precipitation at the time heaving takes place.

We know that clay holds a large part of its moisture in a combined state that does not permit freezing; thus, with equivalent total amounts of water, silts and sands expand more upon freezing than do clays. Further, clays tend to impede the movement of water more than sands. We often find our greatest damage from frost action in situations where the pavement lies on a poorly drained sand, especially fine sands or silty fine sands.

Soils as encountered in the field are very seldom uniform, and the subgrade is especially variable where we go from cut

[3] Bouyoucos, G. J., "Movement of Soil Moisture from Small Capillaries to the Large Capillaries of the Soil upon Freezing," *Journ. Agr. Research*, 24 (No. 5): 427. 1923.

[4] Lebedeff, A. F., "Die Bewegung des Wassers im Boden und im Untergrund," *Zeit. Pflanz. Dung.*, B. 10, s. 1–36. 1927.

to fill as is the case in a rolling country. It has already been pointed out that soil horizons vary greatly in their physical properties. In going from cut to fill the pavement crosses these soil horizons, as is illustrated in Figure 10. As a result, in freezing weather we have large variations in the amount of heaving and the pavement is bound to be damaged by the unequal pressures. This type of damage is prevalent in most of the rolling, till plain areas studied where such soils as the Onoway, Miami, Napanee and Isabella series occur.[5] Often we find that in cer-

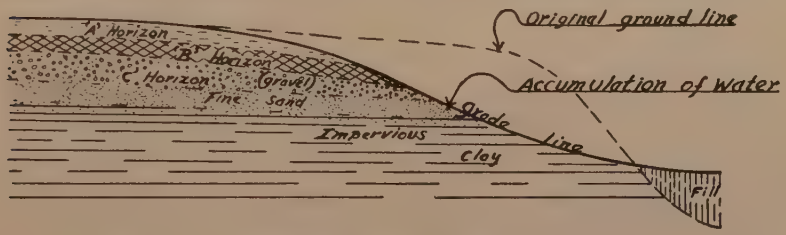


Fig. 11. Longitudinal section of grade, sketched from observations east of Brighton on U. S. Highway 16

tain soils where deep cuts are made the 'C' horizon may be stratified in such a way as to give us the same effect that we observe in the soil profile. Several soils, such as the Allendale, Ogemaw, Ottawa and Berrien series, are developed upon formations consisting of sandy material, often wind-blown, lying over impervious clay. It is obvious that cuts in soils of this type are especially likely to give trouble.

Many cases have been called to our attention where a heavy clay layer or other impervious structure may prevent drainage and give rise to an accumulation of water. This may be a zone of clay concentration ('B' horizon of certain soils), bed-rock, or some other stratigraphic feature. Figure 12 shows how this may be effective in a cut on a side hill. This diagram is drawn from observations on a location east of Brighton on U. S. Highway 16. In this case the 'B' horizon of the Fox loam serves to prevent free drainage and seepage water is allowed to ac-

[5] See Figure 8 for the profile of the Miami series. Onoway, Napanee and Isabella are quite similar in physical condition, except that the Napanee series is considerably heavier.

cumulate under the pavement. Figure 11 illustrates a condition existing on the same road. An impervious clay layer is overlain by layers of silt, fine sand and gravel. All these layers are crossed by the pavement and considerable damage has resulted.

Crystalline rock may prevent drainage and give rise to an accumulation of water under the pavement (Fig. 13). This condition was observed on U. S. Highway 41 between Marquette

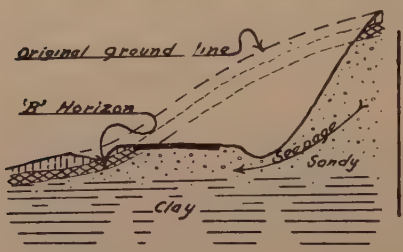


FIG. 12. Cross-section of grade showing how the 'B' horizon may be a factor in preventing drainage in a side-hill cut

FIG. 13. Longitudinal section of grade. This condition exists on U. S. Highway 41, between Marquette and Negaunee

and Negaunee. The pavement through St. Ignace on U. S. Highway 31 lies directly on the limestone in several places and the rock is close to the pavement elsewhere, yet no damage had been observed from this cause. This difference has been found to be significant. In the limestone rocks the breaks and fissures in the rock seem to afford sufficient drainage.

Another serious condition arises in the low, flat, sandy areas where drainage is impractical or impossible. For example, just south of Alpena on U. S. Highway 23 there is a low-lying sandy plain which has a high water table. The soils developed are all very sandy.[6] Because of the proximity to the lake, drainage is practically impossible. Owing to the comparatively even topography, little grading was done. As a result, the pavement rests just above a saturated sandy soil, especially during the winter and spring freezing weather. Much heaving has occurred and only the uniformity of the soil has saved large strips of pavement from complete destruction. The only effective method

[6] The soils were recognized as types of the Saugatuck, Newton and Eastport series.

now known to remedy this situation is to elevate the grade sufficiently, so that the pavement is well above the water table.

Not only do we have sharp contrasts when crossing the horizons of one soil type, but also when crossing the borderland between types. If we take, for example, the Miami series, we find several variations from the typical (if we may use the term "typical" in the sense of "average"). In many places we have found the typical Miami profile to be underlain by fine sand at depths of four to fifteen feet. This same condition has been observed in the Isabella series. The effect of these various conditions is sometimes beneficial and sometimes harmful. In cuts where the Miami profile is underlain by pervious sand, no drainage structures may be needed, while in the typical Miami elaborate structures may be necessary to prevent frost action. Near Novi on U. S. Highway 16 there is a typical Miami profile underlain at considerable depth by an impervious, slate-colored, sandy clay that was probably laid down in a previous glacial period. Between these two heavy materials is a layer of sand in which water may accumulate. The pavement is ruined where it crosses these layers in a cut.

These few examples herein presented will serve to show the great importance of soil studies in planning proposed highways. Where it is possible, the route chosen for a concrete pavement may be selected according to the types of soil, after previous observations have shown which types are best suited for subgrades. Where the route has been established, a detailed soil survey will give information as to what situations will be encountered and the designs may be made accordingly. It cannot be expected, however, that definite rules can be established for each type and followed blindly. Each location will have its own peculiarities. These individual cases must be studied in the field by men whose knowledge of the general relationships give them sufficient background for judgment. It is believed that a more careful consideration of soil character will aid in the perfection of better subgrade design and lead to the construction of highways of greater durability.

Michigan State Highway Department

GEOGRAPHY OF THE SOILS OF SCOTLAND*

JETHRO OTTO VEATCH

SCOTLAND is rich in historic and scenic interest and its people and institutions have exerted a widespread influence upon civilization. There is a voluminous literature dealing with the country and the people. Aside from poetry, novels and general literature, there are numerous scientific publications on the physical features and scenery, the geology, the botany, the zoölogy, the climate, and the agriculture, and many of these publications are classics. But, as is true of most other countries also, there has been relatively little published about soils per se, that is, from the purely pedologic viewpoint. Since, however, civilized agriculture has been carried on in Scotland for several hundred years and in some parts of the country has reached a high stage of development, some reference to soils in agricultural investigations and in geographic descriptions could scarcely be avoided. But it appears that the soil has been generally described in terms of its environment rather upon the basis of systematic classification and upon the intrinsic characteristics of the soil itself. References to geographic distribution of soils have been made upon the basis of the distribution of the old geologic formations or upon the glacial drift overlying them; or in relation to natural features, as "heather soils," "moor soils," "carse soils," "Lowland soils," "Highland soils," etc. Comparisons have been made in terms of productivity under existing agricultural practices, while the laboratory studies of soils have been pretty largely confined to plow soil, or to land under cultivation, and with reference to some particular farm crop or agronomic problem, rather than in re-

* This paper was presented before a joint session of the Sections of Forestry and Geography.

lation to profile and taxonomic type. In these statements no disparagement is intended inasmuch as this condition has obtained throughout the world, at least until very recently.

It is the purpose here to describe briefly, and in a tentative way, the soils of Scotland, according to their regional characteristics and the distribution of broad taxonomic groups, rather than to present a technical paper based upon details of chemical and physical studies of samples in the laboratory. The paper, therefore, is essentially geographic in nature as well as pedologic. The observations presented were made during my appointment, in 1925, by the International Board of Education of America, for the purpose of conducting studies in soil classification in coöperation with the three national agricultural colleges of Scotland located at Edinburgh, Glasgow and Aberdeen.[1]

SOILS, GENERAL CHARACTER

The soils are not as homogeneous or uniform as one might infer knowing the small size of the country, a total area of only 29,796 square miles of land surface, and its relatively small extent, an extreme of only 274 miles of latitude including the outermost island. There are at least three families, or subfamilies, of soils and a very great number of types based upon differences in texture and other physical and chemical peculiarities. All the great classes of soils are represented: (1) common mineral soils (Communisols); (2) organic soils (Plantasols); (3) rock soils (Lithosols); and (4) water soils (Hydrosols). There is a range from tundra-like and the barren rock soils of high mountains, through peaty moor soils to something approaching the character of the "gray-brown" forest soils of the glaciated region of northern United States, but without as completely a developed soil profile. The textural classes, sands, sandy loams, loams, silt loams, clay loams and clays are all represented, and, excluding the peat covering, textural and other wide variations may be observed within short horizontal distances. The impression gained from extensive observation is that sand textures are relatively small in the aggregate of arable land,

[1] The writer wishes to express here his appreciation for favors and courtesies on the part of officials and colleagues in both America and Scotland.

and that loams are perhaps most common. A surface soil of peat or peaty mold under natural conditions, and excessive stoniness are perhaps most generally characteristic.

There is no evidence of either a conspicuous amount of leaching, or on the other hand of enrichment, of parent or underlying inorganic geologic material such for example as may be observed in the mature profiles of the "yellow" forest soils of warm temperate humid regions and the black and brown soils of subhumid and arid regions like those of the Central Mississippi Valley and the Great Plains of the United States. The chemical composition, therefore, may be expected to be essentially that of the underlying glacial drift, if the superficial covering of peat in virgin soils and the highly artificial plow soils are excluded. Since there is a wide range in the lithologic nature of the rocks and drift, corresponding differences in the ultimate chemical analysis may also be expected. The inferred chemical changes which have taken place through soil-forming processes are those due primarily to waterlogging. Otherwise there has been some staining due to infiltration of humic compounds, and a very minor amount of leaching. The deep peat deposits and peaty covering of virgin soils may be expected to exhibit the peculiarities common to this class, namely, relatively high nitrogen and carbon and relatively low amounts of inorganic constituents. Upon the basis of field tests it appears that these organic soils are likely to be generally highly acid.

In general, the soils can hardly be regarded as "poor" in the sense that there is a deficiency in the total amounts of so-called essential inorganic elements, although most of the land is "poor" in an agricultural sense, because of excessive moisture and coldness of soil, extreme stoniness and small thickness of detrital matter over hard bed rock, or because of a thick covering of peat. As is well known, much of the land could not be utilized for cultivated crops, even if the soil were cultivable, because of adverse climatic conditions.

The distinctive pedologic process has been the concatenate accumulation of a peaty surface covering, the reduction of inorganic matter underlying, and the development of "ortstein" and subsurface humic horizons; this in contradistinction to leaching and

MAP 8. Showing soil groups of Scotland

L (Lothian Group). Thin peat covering. Heather and forest. Slightly podsolic
G (Grampian Group). Thick peat covering. Grass and heather moor. Brown humic horizons, hard-pans
B (Ben Nevis Group). Thick peat covering. Glei. Barren rock, high mountain soils

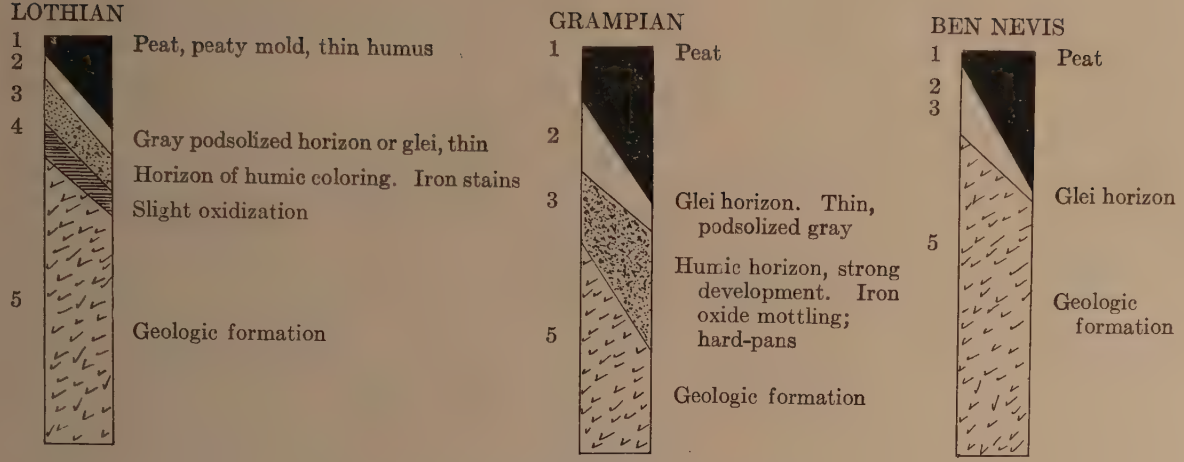


FIG. 14. Profiles of soil groups, Scotland

accumulation of clay-colloid horizons in temperate regions; lateritization in the tropics; and the formation of carbonate horizons and alkalization in semi-arid and arid regions. Were the land surface without marked relief, it would be composed entirely of vast bogs and dreary moors, under the climatic conditions prevailing. Accumulation of peat is rapid, especially accretion in thickness and area of bogs, so much so that it has been destructive in places and has completely buried pine forests. Destructive erosion has been a counteractive force to excessive accumulation, and elsewhere the slope of the land, in conjunction with pervious substrata, has permitted subsurface drainage, thus lessening the amount of water held and retarding peat accumulation.

TAXONOMIC GROUPS

The soils in general are podsolic, in the respect that at least some evidence of leaching, although generally minor, is present beneath the peat or peaty mold, where a climax profile is developed. There appears, however, to be no true forest Podsol, and nothing which is precisely the same as the "gray-brown" and "Braunerde" forest soils of the United States and continental Europe. At high altitudes there is probably something not greatly unlike "Tundraboden" in that the drift or rock underlying the mossy and peaty covering is simply bleached or simply stained by iron compounds, but here there is no permanently frozen ground. There is a resemblance to published descriptions of "Moorboden" of northern Europe, but here again the climatic conditions and consequently the profile are perhaps not precisely the same.

On the basis of the observations made, the opinion is expressed that at least three broad divisions of soils, of the rank of families or subfamilies, should be recognized. The distribution of these groups is shown on the accompanying map (Map 8), and their generalized profiles in Figure 14. These groups are designated by local geographic names for convenience of description.

The Lothian group of soils is characterized by: (1) a rela-

tively thin peaty covering or thin humous layer; (2) a thin leached horizon; (3) a weakly developed "brown" subsurface horizon or a mottled horizon in the case of the heavier and wetter soils; (4) a faint but recognizable development of a horizon in which reddish and yellowish oxidation colors are present and in which there may be a slight increase of colloids over the parent material.

This group is capable of subdivision into a large number of types, since there is a wide range in the texture of the parent materials from sands and gravels to fine plastic clays; in colors of parent material; and in the lithologic composition of the rocks and drift from highly acidic to highly basic. The plow soils are generally some shade of brown, due in part to original peat and humic coloring and in part to heavy manuring under cultivation.

This group lies mainly in the Central Lowland and the eastern part of the country, where it occupies in general a position from sea-level up to altitudes of 600 to 900 feet. On the western side there is a much smaller aggregate and the range in altitude is less. The Lothian group comprises probably not more than one fourth of the total area.

The Grampian group of soils is characterized by: (1) a relatively thick peat covering; (2) a relatively thick bleached or "glei" horizon in the case of heavier soils, or a thin leached horizon in the lighter; (3) a horizon marked either by a brown organic color, or by rust-colored staining, spotting and veining, or by hard-pans. There is practically no development of yellow or red colors which are the result of oxidation of iron minerals under conditions of low moisture or good drainage and practically no accumulation of inorganic colloids resulting from soil-forming processes.

In the virgin soil practically all the vegetation is growing in the peaty covering. On the cultivated land the plow soil is generally brown or umber-colored, owing to the influence of the peat and the brown subsurface staining, but may be grayish in some places where the texture is heavy and a thick "glei" horizon has been developed. A large number of types may be

recognized in this group, based upon the thickness of the peat covering, the texture and lithologic composition, and the thickness of detrital matter over the bed rock.

The Grampian group comprises probably more than one half of the total area of the country: the soils of most of the country north of the Clyde and north of Inverness, and most of that of the islands, while in the Southern Highlands it includes most of the land above 900 or 1,000 feet.

The Ben Nevis group comprises soils characterized simply by a covering of peat over a "glei" horizon. There is very little development of the "brown" horizon, owing to infiltration of humic compounds, and no accumulation of inorganic colloids due to soil-forming processes. Disintegration is dominant and the detrital matter is, therefore, almost wholly psammogenous. Over a great part of the land the thick peat covering is missing because of precipitous rock slopes, water and wind erosion, and landslides, so that the soil is simply hard rock upon which there may be only lichens or a thin mat of living vegetation, or it may consist of avalanches of broken rock, the interstices being filled with peat and sand and gravel. The Ben Nevis group occupies a smaller total area than the other two groups and is present chiefly at altitudes above 2500 feet.

In addition to the classified soils just described there is a considerable aggregate of miscellaneous soil and land consisting of: deep peat deposits; shifting sand dunes and ocean beach or strand; and recently deposited alluvium. The peats are almost universally brown or yellowish, raw or highly decomposed, strongly acid, coarse in texture, matted and spongy or in felt-like layers. They appear to represent for the most part accumulations on flat or basin-like land surfaces rather than filling of lakes, and on most of the deposits the accumulation is still in process.

SOILS IN RELATION TO ENVIRONMENTAL AND CAUSATIVE CONDITIONS

There is a fairly close correlation between the nature of the soil and the geologic formations, both the old country rock

and the glacial drift. This follows, first, since the drift is thin over the greater part of the area, and in many places is absent, and, secondly, because, owing to the prevalence of a peaty covering, there is little possibility of oxidation and complete alteration of rocks and minerals by weathering processes. Certainly there is less alteration than in the glaciated region of the United States where the land surface is probably no older, measured by the date of the final retreat of the ice-sheet. But even so, it does not follow that types of soils will necessarily coincide with boundaries of geologic divisions even on the most detailed geologic maps, since types must be based to a large extent on fine textural distinctions, and since moisture or drainage conditions and consequently the covering of peat and other profile differences may vary greatly on the same formation. Given the same underlying rock, the soil conditions are quite different at 3,000 feet as compared with sea-level, or a few hundred feet, near Edinburgh.

There is a close correlation between the soil groups and differences in elements of climate. The climate in general is moist and cool, but without any great range in temperature, neither excessively cold nor hot. The mean annual temperature at Edinburgh is 47° F., and the range between July and January temperatures is only about 19 degrees. The precipitation varies from 25 to 35 inches on the North Sea side to 40 to 80 inches on the Atlantic side, at the lower elevations, while it is probably as much as 150 inches on the top of Ben Nevis.

The distribution of the Lothian group of soils can be, in general, correlated with the region of lower precipitation, higher temperatures and higher sunshine; the Grampian group with higher precipitation and greater humidity; and the Ben Nevis with the highest precipitation and lowest temperature. Snow and temperatures considerably below freezing are common in winter at the higher altitudes.

The existing soils have been influenced most by smaller vegetation, grasses, sedges, mosses, and Ericaceae, and less by forest. In the region of the Lothian soils there may have been originally considerable forest, possibly oaks, ash, maple and Scotch pine, but heather is also characteristic, consisting

of the species *Calluna vulgaris* and *Erica cinerea*. Here the gorse, *Ulex Europaeus*, and broom, *Cytisus scoparius*, are also common.

In the region of the Grampian soils, the "wet" or "grass" moor is more characteristic, containing such species as *Nardus stricta*, *Molinia caeruluea*, *Deschampsia flexuosa*, *Festuca ovina*, *Juncus squarrosus* and *Scirpus caespitosus*. Common in this region are blueberries, *Vaccinium sp.*, crowberry, *Empetrum nigrum*, bearberry, *Arctostaphylos Uva-ursi*, mosses and bracken. Some forest appeared in the glens and in the more protected places, particularly the Scotch pine and the oak, *Quercus sesquiflora*, but in general the soils are nearly treeless under natural conditions.

The vegetation characteristic of the Ben Nevis soils are mosses and lichens and species of Saxifraga, Draba, Carex, Silene and Festuca at the higher altitudes and in the most exposed situations. Bearberry and crowberry and other small shrubby vegetation are present, but trees are entirely absent, other than an occasional dwarf willow.

HUMAN RELATIONSHIPS

Whether worked out according to climate, geologic divisions, physiographic divisions or soil divisions, pretty nearly the same relationships with agriculture and use of land, distribution of population and social conditions obtain. The correlation between soils and agriculture is apparent even from the most casual study. While no painstaking statistical comparisons have been made, it is probably safe to state that at least 75 per cent of the farms, cultivated land, and rural population is restricted to the Lothian group of soils. These soils are principally in the Central Lowland, on the benches bordering the sea, and in the wider straths at elevations generally less than 900 feet. They comprise perhaps less than one fourth of the total area.

On the Grampian group of soils there is mostly grazing of sheep, a small amount of cultivated land, large estates and game preserves, a meager rural population, poverty, and a bitter strug-

gle for the necessities of a bare existence for the tenants and the landless. The soil on which profitable farming is carried on lies chiefly at low altitudes not greater than 500 or 600 feet and mainly on the Atlantic side. The Grampian soils comprise probably more than one half of the total area.

On the Ben Nevis group of soils there are no agriculture and no permanent population. It is not improbable that there are over five million acres of land in Scotland that is literally waste in the sense that it has no value for agriculture, the grazing of domestic animals, or for afforestation. For the most part it constitutes scenery here weird or fantastic, there beautiful and grand, and in many places as desolate and dreary as can be imagined.

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SOME GREENLAND SAND DUNES

RALPH L. BELKNAP

WIND action is commonly considered as being effective only in arid regions or along the shores of large bodies of water. That is, it is confined to areas more or less flat where there is a long sweep, and to areas where the bare rock surface is exposed to the blasts of the sand-filled air.

In the summer of 1927 several trips were made from the base camp of the University of Michigan Expedition, located as shown in the map of the Holstensborg district (Map 9) at the head of navigation on the Söndre Strömfjord over one hundred miles inland from the coast and in a latitude of slightly less than 67 degrees. The trips were for the most part to the ice-cap which is about twenty-five miles farther inland. On these trips a number of observations were made relative to the effect of wind action. A brief description of the features and conditions observed with reference to wind action is presented here with the hope that some valuable suggestions may be given toward the solution of this much-discussed problem.

Although Greenland is by no means to be considered as an arid region, yet within a narrow hinterland zone in the Holstensborg district close to the inland ice certain conditions favorable to wind action are to be found.

Nordenskjöld, who made his trip into the interior of the Holstensborg district in 1909, has described this area as being steppe-like. This is indicated more clearly by observations taken by Church, one of the meteorologists of the University of Michigan Expedition. He found that the average relative humidity in the interior, between the middle of July and the last of August, was 63 per cent.[1] The low humidity is explained

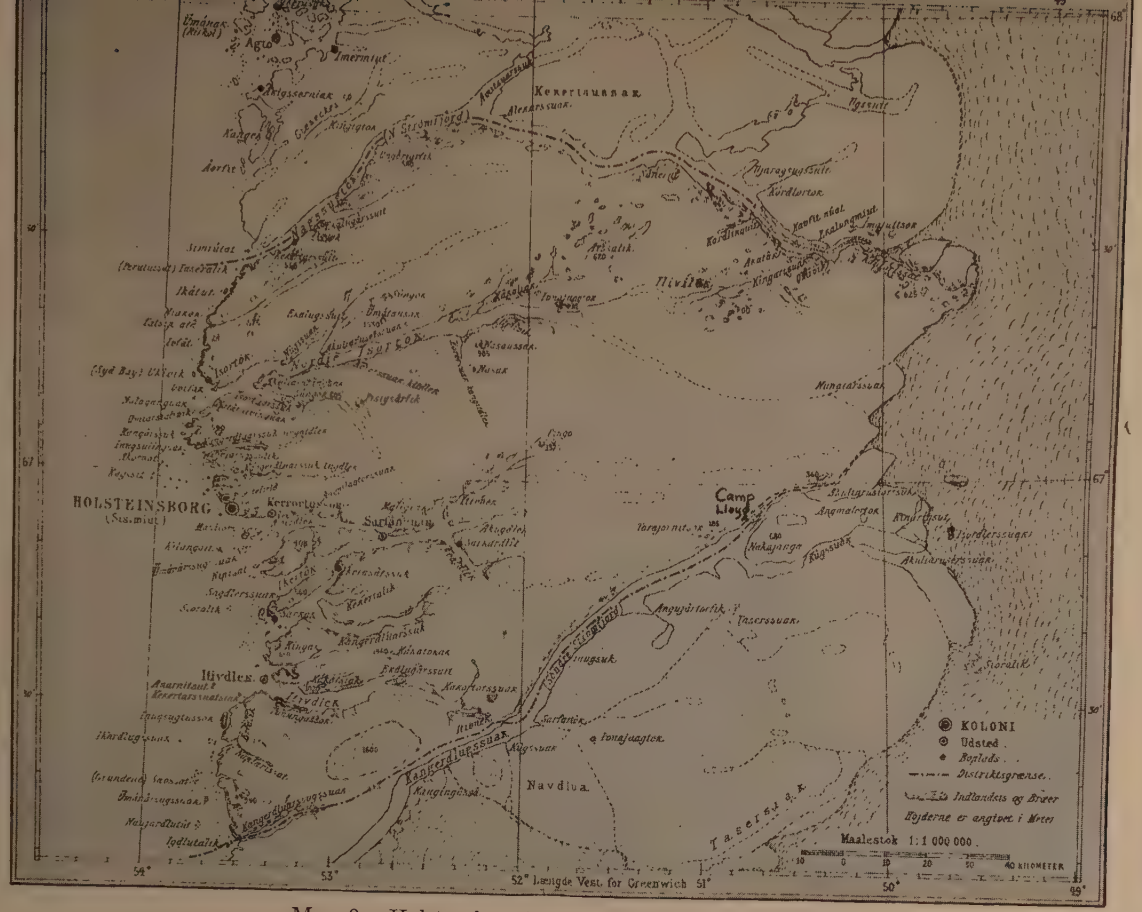
[1] From unpublished data kindly furnished by J. E. Church.

by the fact that moderately warm weather with clear skies and practically continual daylight is the predominant climatic characteristic of the region.

Another characteristic of importance is no doubt due to topography. The region is, as a result of its being glaciated, of moderately high relief. It is quite regular, though cut by wide valleys which run out almost perpendicularly from the ice front. With monotonous regularity the wind blows down from the ice through these trough-like depressions. Not only does it blow consistently from the same direction, but it frequently blows with a very high velocity. In one wind-storm during July of 1927 the velocity in gusts was recorded as 120 miles per hour, and for a period of over an hour maintained an average of 72 miles per hour. Later observations have shown that this was not an exceptional storm, as similar ones may be expected at least several times during the year.

For the wind to be an effective erosive agent it must have, in addition to a high velocity, tools with which to work and also bare rock surfaces upon which to act. Glaciation is again important in providing both of these. As a result of glacial erosion the bare rock surfaces are usually exposed, since there are little soil and vegetation to protect them. In addition, as the ice melts back, there is supplied continually to the wind as it sweeps down off the edge of the ice a fresh supply of unconsolidated material to be dried out and picked up, and this serves as a tool for its abrasive action. The effectiveness of its action can best be determined by a study of the results observed.

Inasmuch as the rock exposed in this area is predominantly gneiss with occasional intrusions of highly basic material, but all very highly metamorphosed, it is not easily eroded. In at least two places erosional effects were found which are believed to be in part attributable to wind action. The first effect is shown in the picture (Pl. XVI, Fig. 1) taken opposite the first or lower rapids of Watson River. The pot-holes and larger depressions in the surface of the fine-grained basalt and gneiss were undoubtedly formed by water action. At the present time, however, this surface is above the level reached by the



MAP 9. Holstensborg District, showing Camp Lloyd

stream. There are two characteristics shown here which seem to indicate that wind action has been partially responsible for the present condition. In the first place the surface is smoother than it would be if acted on only by water. It is a polished surface. The lighter parts of the surface shown in the picture are due to the light being reflected so perfectly from the polished surface of the rock. It was also observed that the ridges between the depressions extended in nearly every direction and particularly transverse to the direction the water must have taken when the depressions were formed. If they were due entirely to water action, the ridges would be expected to have a direction roughly parallel to the direction of flow. A closer examination shows that many of these little ridges are sharp-crested. Again this would hardly seem to be the result of water action, since in that case the material rolling along would rapidly round off the crests between the hollows. It appears, then, that stream action is responsible for the general condition, the formation of the pitted surface, while wind action has eroded a little, but its action has been primarily to polish the surface over which it moved. This conclusion was considered more tenable after a similar polished surface had been examined farther inland. In this latter place, however, the polished surface was found near the top of a ridge far above any possible level reached by the stream.

In contrast to the limited erosive action of the wind there are many evidences of its work as an agent of transportation. From near the edge of the ice, clouds of fine loess-like dust are often seen blowing down the valley. This fine material may be found miles away from the edge of the ice, forming a thin coating over the vegetation and the surface of the ground. The coarser material is carried and rolled down along the wide valley flats where it is deposited temporarily, to be picked up again and eventually deposited higher up on the side of the valley unless it has lodged in a stream and been carried away. In the quieter periods the sand, frequently ripple-marked, accumulates over the surface of the drier parts of the sand flats. After a severe wind-storm, however, the surface (Pl. XVI, Fig. 2)

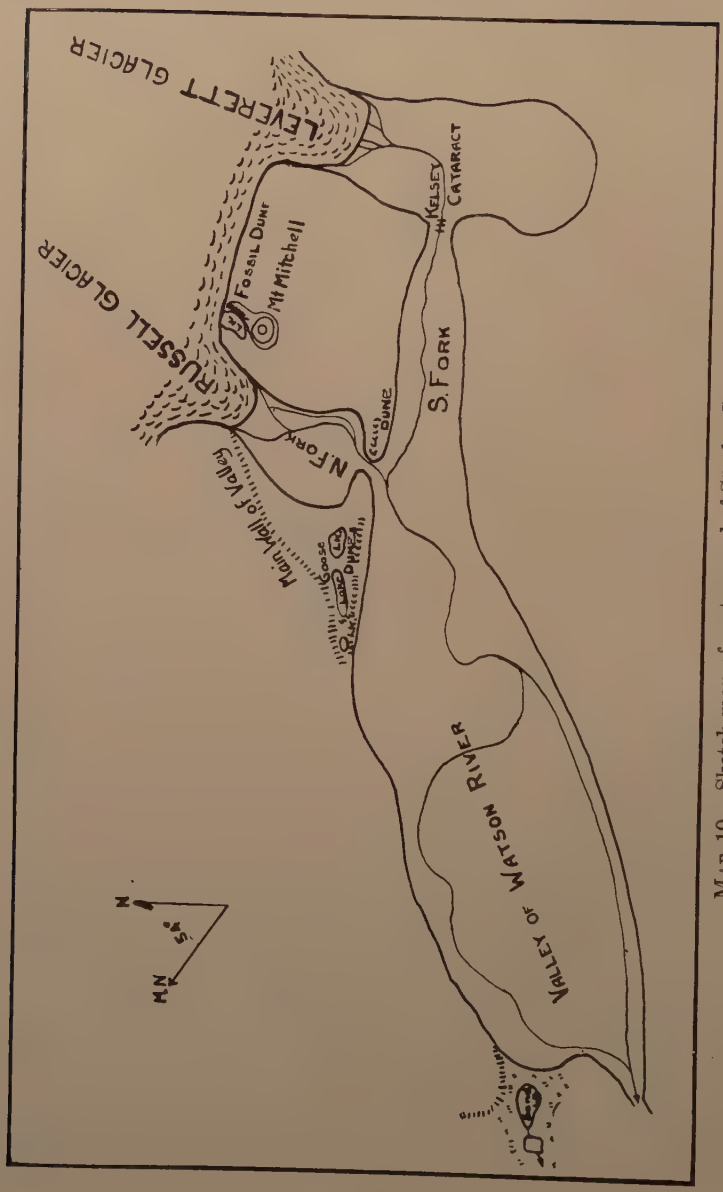
is covered by a protective armor of large pebbles, the finer material having been removed.

The most important evidence of wind action under ordinary conditions is found in the accumulation of sand, particularly on the northern side of the valley, both at the foot of the valley wall and on terraces along the side of the valley.

The largest single deposit occurs as a dune opposite the narrows on the north fork of Watson River. It is shown in the diagram (Map 10) that the two upper branches are joined at this point. The material is brought primarily from the north. The wind coming down from the ice strikes the rock ridge, which checks its velocity slightly, but it is reduced still more as it meets the air moving down the other fork. The result is that a dune is formed as a continuation of the ridge separating the two valleys. The dune is long, narrow, sharp-crested, composed of relatively fine material, and is deposited in rather regular layers (Pl. XVII, Fig. 1). In the lower part of the south side a few thin layers of carbonaceous material indicate that the development of the dune has been interrupted. At the present time the dune is built out to the west so far that additional material will for the most part be deposited in the stream at its base.

Another ridge composed primarily of sand extends from the present ice border southward to Mt. Mitchell (Pl. XVII, Fig. 2). This deposit must have been formed by wind action at an earlier time, since it is to be considered now as a fossil dune, the sides being covered with vegetation.

Much has been written on the subject of sand dunes, particularly their origin, but as yet the problem of their exact origin is still unsolved. Several theories have been advanced, but no one of them seems to fit all cases. There is, of course, general agreement on the point that, as in the case of stream action, there must be a decrease in velocity. This may in some places be due to obstructions such as vegetation, or it may be brought about by the eddies caused as the air moves over the irregularities of the surface. This discussion is now given because the reasons for the deposition of sand here appear so evident and because it may suggest possibilities in other conditions.



Map 10. Sketch map of eastern end of Söndre Strömfjord

In this discussion the various theories of origin are omitted, but the apparent cause of each deposition is indicated.

The statement that the winds blow down the valley is in general true. A closer study, however, shows that at least in the upper, shallower part of the valley, because of the predominating influence of the inland ice, there is a tendency for the air to move in a direction somewhat diagonal to the main valley, and as a result the wind carries its load to the northern side of the valley.

The first definite accumulation of wind-blown material occurs at the foot of the ridge previously described. From a distance of about one hundred feet in front of the ridge the sand slope rises at an increasing gradient until the sand rests against the steep wall of the ridge or at the eastern end, where the wall is higher and steeper, until it reaches a point three to five feet in front of the ridge, where it drops down a steep back slope into a moat-like depression sometimes as much as four feet deep. Such a depression occurs only where the wall is nearly vertical to overhanging, apparently due, then, to the fact that the wind moving almost parallel to the wall is reflected back from the steep wall, thereby preventing the accumulation of sand at its base. The quantity of material deposited here is limited, as most of the sand is carried up, over the top, where it is deposited, burying the top of the ridge and forming a long narrow dune parallel to the ridge. This deposit has a steep back slope (Pl. XVIII, Fig. 1) away from the ridge on the lee side. In each of three places in the narrower western end of the upper valley a large amount of sand has been blown through a break in the ridge forming a deposit clear across the valley, thus damming the outlet and forming three small lakes. At the present time the outlet to the middle one, Goose Lake, is to the south in a channel maintained through the dune to a break in the ridge; this outlet is at right angles to the direction of the former stream.

In the dunes just described the deposition is caused by an obstruction, the rock ridge. This is indicated more clearly by the fact that the deposition forming the barrier across the valley always occurs just below, not opposite, the break in the ridge.

In a wider part of the valley about four miles farther west

this same condition is repeated, resulting in the formation of Sand Lake. Here, however, the barrier is formed in part by a moraine that crosses the valley.

Undoubtedly the most of the deposited material occurs in very small dunes located on the rather flat slopes along the northern side of the valley. These dunes are again caused by an obstruction consisting of the vegetation, usually willow. Quite frequently very small dunes or accumulations of sand are found on the drier parts of the sand-flat, where the material has started to accumulate around fire-weed or "bunch" grass. That dunes of this type migrate rapidly is indicated by the frequent occurrence of long bare willow roots, which are uncovered as the dune migrates.

It is not unusual for these small dunes to widen and for the vegetation in the center to die, so that the wind is most effective through the middle. This soon results in the formation of a depression through the middle which is rapidly deepened until there is formed a "blow-out" or horseshoe-shaped dune (Pl. XVIII, Fig. 2) with the concave side toward the direction from which the wind is coming. Very shortly, however, the wind cuts completely through the dune, forming two longitudinal ones. These are of an erosional rather than a depositional type, but are of the most common occurrence along the side of the valley.

To summarize this discussion in reference to the depositional features formed, the following facts should be emphasized. Although there is some very fine loess-like material deposited rather uniformly over a large area and in some places at a considerable distance from the ice, most of the material is found on the sand-flat or on the terraces along the side, particularly the north side, of the valley. The deposition is always due to an obstruction. In the larger dunes a rock ridge forms the obstruction; the deposition occurs mainly in the lee of the ridge. In the small dunes, vegetation has formed the obstruction. In the former case the deposits sometimes blocked drainage lines, thus forming lakes. In the latter, erosional types have resulted from the removal of material along the medial line, forming blow-outs and, eventually, longitudinal dunes.

University of Michigan

PLATE XVI

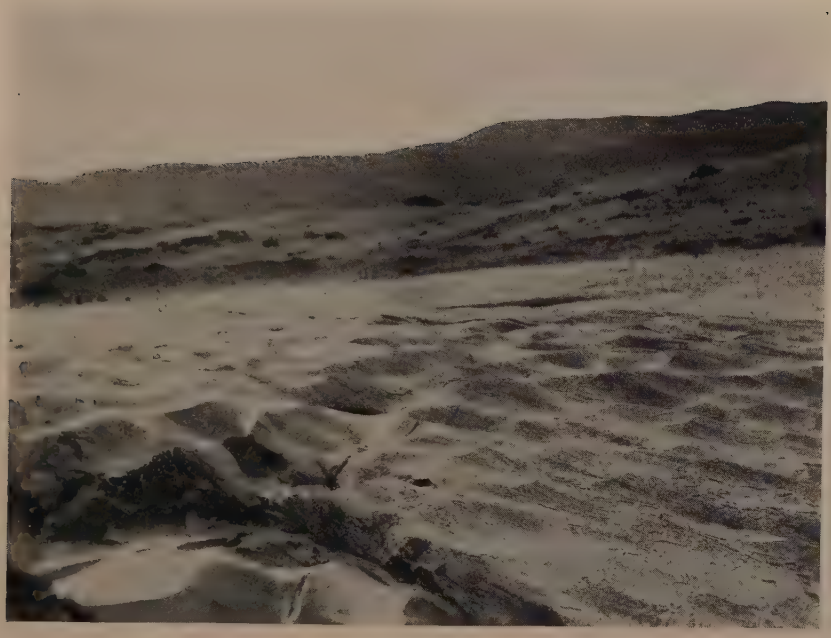


FIG. 1. Polished rock surface opposite the first rapids of Camp Lloyd

FIG. 2. Pebbly surface of sand-flat after a storm

PLATE XVII

FIG. 1. Sand dune opposite Upper Narrows, Watson River

FIG. 2. "Fossil" dune at edge of ice

PLATE XVIII

FIG. 1. View of lee side of sand dune opposite Goose Lake

FIG. 2. "Blow-out" or Horseshoe dune

AN EXCEPTIONAL SPECIMEN SHOWING RHYTHMIC BANDING

CHARLES W. COOK

THE paper on the progress of replacement and the formation of nodules [1] which was presented before the Academy last year has produced an influx of specimens showing phenomena bearing on that subject. It is the purpose of this paper to describe one particularly fine specimen which not only affords definite support of the ideas advanced in the earlier paper but also clearly demonstrates that the nature of the action may vary with a change in conditions.

DESCRIPTION OF THE SPECIMEN

The specimen, which is shown with the natural surfaces in Plate XIX, Figures 1 and 2, and with one surface polished in Plate XX, Figure 1, is a rectangular cleavage fragment, approximately ten inches long, eight inches wide, and one inch thick. It is bounded on four sides by joint planes and on two sides by planes of schistosity. According to such information as is available, the specimen was found in the glacial drift near Ann Arbor. It seems probable that it came originally from the pre-Cambrian area to the north.

A microscopic examination of thin-sections from the specimen shows that the rock is a sericitic schist, the essential constituents of which are sericite, quartz and the oxides of iron, hematite and limonite. The hematite and limonite are segregated into two zones, the hematite occurring in the outer zone (see Pl. XIX, Figs. 1 and 2), and the limonite in the inner zone. The more even distribution of the hematite in closely spaced rhythmic "rings" gives a red color to the outer zone, whereas the unequal distribu-

[1] *Papers of the Mich. Acad. Sci., Arts and Letters*, VIII (1927): 285–292.

tion of the limonite in the inner zone causes the color to vary from light buff to dark brown. The outer red and inner buff zones are separated from each other by a heavy band of limonite. A second heavy limonite band divides the inner zone into two subzones. This shows especially well in the photograph reproduced on Plate XX, Figure 1.

It is to be noted that the "rings" in each of the zones show decided differences in form. In the outer, hematite zone, the "rings" conform closely to the form produced by the joint planes; the heavy limonite band separating this zone from the limonite zone also tends to conform to the joint form. Within that part of the limonite zone between the two heavy bands of limonite, the tendency toward a spheroidal shape becomes apparent in the "rings" and this tendency is very marked in the inner heavy limonite band, as may be seen from observation of this band on opposite sides of the specimen (see Pl. XIX, Figs. 1 and 2). Inside the inner heavy limonite band, the "rings" conform to neither the joint form of the specimen nor to the spheroidal form of the inner heavy limonite band. Instead they appear as a series of overlapping waves with the inner margins convex rather than concave toward the center of the specimen. This shows especially well in the photograph of the polished surface (Pl. XX, Fig. 1).

Another feature of the specimen to which attention should be called is the difference in the nature of the distribution of the hematite and the limonite. The hematite, although sufficiently concentrated at points to make the "rings" visible in the hand specimen and also in a thin-section, when the section is viewed in reflected light, is so evenly disseminated that the "rings" are but slightly visible in transmitted light. Plate XXI, Figure 1, which is a reproduction of a microphotograph of a thin-section from the hematite band, shows the nature of the dissemination. Although one of the "rings" passes across the center of the section, it is invisible in the microphotograph.

In the limonite zone, in addition to its disseminated occurrence, the limonite has been concentrated also in fractures. The microphotograph of a thin-section from this zone (Pl. XX, Fig. 2) shows such a concentration of the limonite in a fracture. This re-

lationship of the limonite deposition to fractures is also shown at the inner margins of the heavy limonite bands by the pronounced triangular protuberances extending from the bands toward the center of the specimen, along visible fractures.

Chemical analyses by Justin Zinn of samples from the two zones show a much higher concentration of iron in the hematite zone than in the limonite zone, the percentages, calculated as ferric oxide, being respectively 7.53 and 3.65. The analyses also show a slightly higher percentage of silica in the hematite zone, the percentages being 68.40 for the hematite zone and 67.84 for the limonite zone. The microscopic examination shows that quartz is a more prominent constituent of the hematite zone than of the limonite zone, the crystals of quartz being both larger and more numerous (compare Pl. XXI, Figs. 1 and 2).

INTERPRETATION OF THE OBSERVED FACTS

That the hematite deposition and the limonite deposition mark two definite periods of deposition under two entirely different sets of conditions is, I believe, unquestionable. Two other stages in the specimen's history are possibly suggested; namely, a pre-hematite stage and a late limonite stage.

The pre-hematite stage is suggested by what may possibly be the vanishing traces of a concretionary structure. This structure shows in the upper left corner and lower left corner of the photographs of opposite sides of the specimen reproduced on Plate XIX. If this does indicate the existence of a former concretion, that concretion was probably formed in the shale from which the schist has been derived and the traces of it have been largely removed by the process of metamorphism.

A late limonite stage is suggested by the nature of the "rings" within the inner heavy limonite band. These "rings" I have described as appearing in overlapping waves with convex fronts, which suggest diffusion at different times from different centers. The idea suggests itself, although there is no proof, that this marks the stage of migration of the iron during the time the specimen existed as a constituent of the drift.

Since these two stages are merely suggested, let us attempt rather to interpret the two stages which are unquestionably indicated. The lithological nature of the specimen indicates that the rock was formed under dynamo-metamorphic conditions and at depths sufficient to prevent fracturing. After metamorphism it was exposed at the surface by erosion and contributed to the glacial drift. As erosion proceeded after the formation of the schist, the weight of the overlying rock was reduced until incipient joints were formed, along which iron-bearing solutions circulated. The iron, diffusing from the solutions into the joint block, was deposited by replacement of the constituents of the rock in the form of hematite, owing to the demands of pressure for the formation of minerals with small specific volume; and possibly to high temperature. With further removal of the overburden, the incipient joints developed into definite openings. With this reduction in pressure, the deposition of the iron in the form of limonite occurred, both in diffusion rings and along irregular fractures. During the earlier stages of the limonite deposition the influence of the joint planes is apparent in the shape of the "rings." However, as already pointed out, the shape and the interrelationship of the innermost "rings" suggest the possibility of solution and redeposition of the iron previously concentrated in the specimen.

CONCLUSIONS

If the foregoing interpretation is correct, it shows clearly that, during the time iron was being contributed by solutions in the joint openings, the form of the deposit gradually changed from that of the joint block to that of a concretion. Subsequently the action was to diffuse the iron from points of concentration with the formation of "rings" concentric about given points. These "rings" are often observed around a nucleus of pyrite in a weathered pebble and mark dissemination rather than concentration of the iron.

Therefore, I believe that the conclusion stated in the earlier paper[2] to the effect that "concretions do not necessarily represent

[2] *Loc. cit.*

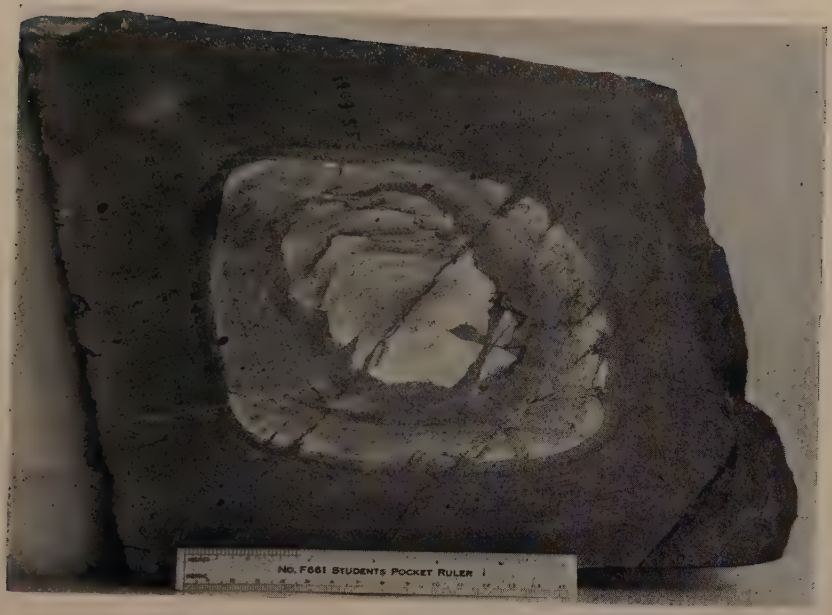


FIG. 1. The original surface of a specimen showing rhythmic banding

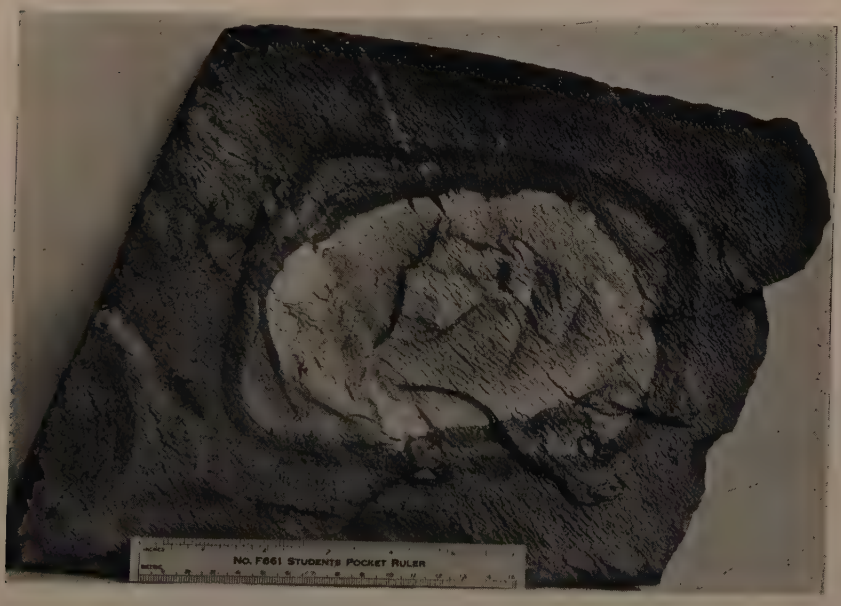


FIG. 2. The original surface of the reverse side of the specimen shown in Figure 1

PLATE XX

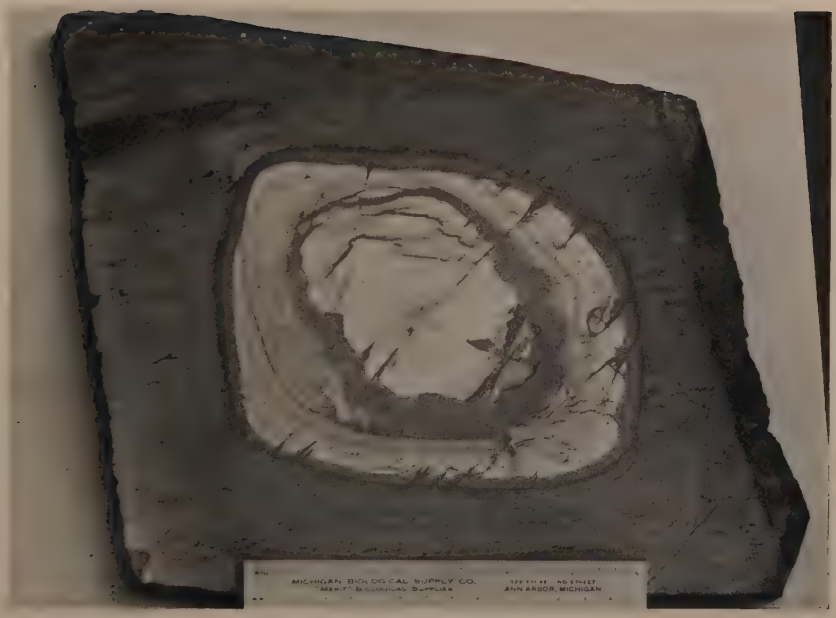


FIG. 1. Surface shown on Plate XIX, Figure 1, after polishing

FIG. 2. Microphotograph showing deposition of limonite in fractures. × 50

PLATE XXI

FIG. 1. Microphotograph showing distribution of hematite and quartz. × 100

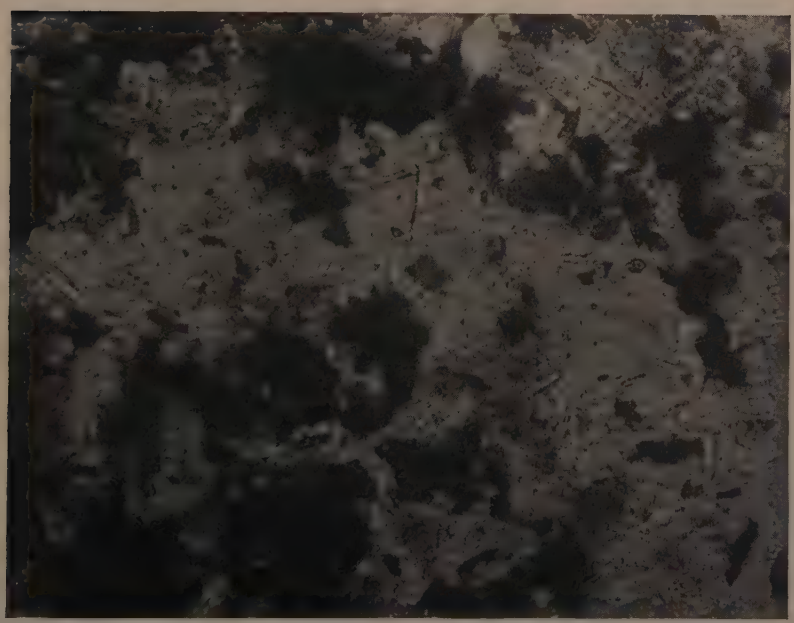


FIG. 2. Microphotograph of section from limonite zone showing the scarcity of quartz. × 400

segregations of minerals around an original nucleus, but may result from the rhythmic deposition of minerals, the constituents of which have diffused from solutions in joint and bedding planes, the shape of the concretions being determined by the spacing of these planes," should be made more positive by stating that concretions are generally formed in this way.

University of Michigan

CORRELATING GEOLOGICAL MARKERS IN MICHIGAN SECTION

ROBERT B. NEWCOMBE

GENERAL ASPECTS OF CORRELATING MARKERS

CERTAIN characteristics of a rock bed or formation may be such that it stands out from all others, or at least from the strata adjacent. Most important among these is the property of color which is more likely to give a contrast that is at once visible and easily distinguished. Those colors that are bright and unusually different from the general character of a section are very serviceable in making a horizon useful as a marker. In Michigan the beds which are red or black have found the most common use in this regard.

Lithologic properties often stand out to make a layer significant as a marker. Hardness and size of grain are most important as they are usually quite easily distinguishable. It is obvious that some shales are harder than others and certain dolomites if not highly porous are harder than limestones. Sandstones are usually intermediate in hardness between shales and limestones and are identifiable by size of grain. The shape and the assorting of grains often make certain sandstones easy to separate from others.

The substances found in a bed are occasionally very unusual and characteristic. Water or brine may have peculiar physical and chemical properties which will serve to identify them if carefully observed. The presence of easily determined minerals like mica and pyrite in shales and of the unusual rare minerals in sandstones often indicate very sharp division points. Paleontologic evidence is paramount in the identification of limestone and calcareous shale horizons when nothing else will apply for accurate separation of one stratum from another. A further aid in identification is the position of one bed above or below another. Neither

may be positively determined separately, but the occurrence together is absolute proof in correlation.

IMPORTANCE OF GOOD CORRELATING MARKERS

If a rock bed is to have significance as a correlating marker, it must have not only definite characteristics which make it easily identified, but also a stable position in the rock column. That is, for at least a given area, the intervals to other beds below and above this formation should not be decidedly variable.

The importance of good correlating markers stands out more vividly in the practical application of geology than in the scientific sense. Subsurface data from wells can be accurately obtained only when easily recognized beds are present, and the entire principle of geological mapping of surface rocks depends on a good key-formation.

Recent shallow testing for structure in Michigan has necessitated a diligent search for suitable key-beds. Strata suitable as markers have been sought out in following the trend of new development. Technology has also demanded accurate data on the relative location in the rock column so as to determine the proper place to set casing, check distances to pay formations, and adjust drilling difficulties.

MARKERS IN THE MICHIGAN SECTION

Some formations of local significance for markers could not be used over a broad area because they vary in thickness, change in character, and are often lacking. Beds of this type in the Michigan section which may be used locally are the red horizons in the Coldwater shale, the Sunbury black shale, the blue-gray Bell shale, and the Sylvania sandstone. Efforts to use the coal seams of the Saginaw formation and the gypsum beds of the Michigan series as key-horizons for structure have been very unsatisfactory. They show unusually high dips due to slumping, and carry uniformly over only extremely short intervals. The nature of their deposition in small local basins practically eliminates them as useful markers. Other formations which occur at great depth in the Southern Peninsula, but which have color possibilities as markers,

are the Guelph white dolomite, the colored shales of the Cataract formation and the Cincinnatian series, and the brown Utica shale.

Several other formations which might have use as key-horizons if it were not for their irregular position are the Parma sandstone and conglomerate, the Bayport limestone, and the red beds of the Lower Marshall formation. The Parma and the Bayport are found at the contact of the great Pennsylvanian-Mississippian unconformity, and are, therefore, decidedly variable even locally. The red, micaceous, sandy shales of the Lower Marshall may be found adaptable in the future, but in thirty wells platted[1] for the limited area of the Saginaw Oil Field, they showed no uniformity in position either at the top or for individual red zones. The bottom of the last red zone may serve as a fairly good index, since it conforms very closely with the top of the Marshall above and the Berea below. The Berea is not applicable as a marker except in connection with the Sunbury black shale, as it is so easily mistaken for local sandstones in the bottom part of the Coldwater formation. The red shale which replaces part of the Berea in the southwestern part of the state may be used as a marker in a few limited localities, but the stability of its position is not certain.

The two formations which have state-wide importance as good correlation markers are the Napoleon or Upper Marshall sandstone and the Antrim shale. Their position in the section is fairly constant and they are nearly everywhere to be found if within reach. Even these horizons, however, exhibit local difficulties and are not perfect checks for correlative purposes. In some places the Antrim occurs together with the Bedford shale, which is gray, but usually the Antrim proper can be determined upon careful examination. The Napoleon is generally a greenish, angular-grained sandstone and regular in its occurrence. The presence of a heavy flow of water and the chemical composition of the brines are added corroborative evidence to separate this sandstone from others. Specific difficulty in determining the Upper Marshall is the similarity to sandstones of the Michigan series and the Parma formation. Associated sulfates with the latter beds alleviate this difficulty.

A red calcareous shale in the Coldwater formation has served

[1] Unpublished data supplied by W. Osgood in a personal communication.

as aid to delineate structural trend at Muskegon. This bed occurs in Muskegon Township at from 800 to 950 feet and has been found in every well drilled in the area. The distance of this horizon from the top of the Traverse limestone in which oil and gas production occurs is remarkably uniform at about 780 feet. In the future the usability of the red marker may be found to be limited, but at the present time it is very helpful in a new development.

One company has done considerable shallow testing of the Upper Marshall formation in the Saginaw Bay region for the purpose of determining structural conditions. It has confined its efforts largely to localities of thin glacial drift and where the Napoleon sandstone can be found at a depth of 200 to 500 feet. Although all the problems which have been encountered cannot be divulged, several matters of correlation show, upon careful examination of conditions, the possibilities of key-horizons. It has been found that locally the Marshall water has a very milky appearance due to suspended material. The flaky white substance in the drill cuttings is evidently kaolinitic or aluminous and microscopic examination[2] shows a possibility of the mineral Gibbsite. No chemical analysis has yet been made of the substance, although there have been efforts to get it into solution by the fusion method. Further studies[3] have been made upon the sulfate content of shales and brines by the use of comparative cloudiness in qualitative tests. Results along this line have been found to be very satisfactory and the method has proved unusually decisive in certain instances.

CONCLUSION

More and more is becoming known of the rock section in Michigan and new correlating markers are constantly being found for practical use. Details which would often pass unnoticed are being carefully observed by those on the lookout for every sign of structure. The rocks of the state contain numerous key-horizons and a great deal can be done in the search for folds by carefully directed shallow drilling.

State Geological Survey
Lansing, Michigan

[2] Examination made by Professor A. B. Peck, University of Michigan.
[3] By W. A. Thomas, of the Pure Oil Company.

STRUCTURAL INFLUENCES ON RECENT MICHIGAN OIL DEVELOPMENT

ROBERT B. NEWCOMBE

PREVIOUS NOTIONS OF MICHIGAN STRUCTURE

THE nature of the major structure of the Michigan Basin has long been understood in a general way. The saucer-shaped outline, the isolated position, and the character as a structural basin of deposition have always marked it as a separate province. Minor structures or local folds that occur within its borders have been considered to be of a type somewhat different from those associated with the usual major structural disturbance. Nearly all these folds are more or less radial to the basin and plunge sharply toward its center. It has been stated[1] that the folds occur mainly toward the margin of the basin and that they are of small size.

In 1922 Robinson[2] advanced the foremost theory explaining the origin of the minor wrinkles occurring around the border of the Michigan Basin. He contended that these small folds were not the usual type caused by lateral pressures, but were more of the nature of wrinkles in the border of the basin and were primarily due to vertical forces involved in the stress relations of the larger feature. His premise was mainly one of depositional settling and compensation according to the irregularities of the basin. Illustrative of this principle would be the crumpling caused in a sheet of paper when pressed into a circular container.

Further consideration arising from this radial arrangement of structures was the facility of drainage out of the immediate Mich-

[1] Smith, R. A., *The Occurrence of Oil and Gas in Michigan*, Mich. Geol. and Biol. Survey, Publ. 14, p. 19; Robinson, W. I., *Possibilities of Oil and Gas in Michigan*, p. 106, Mich. Geol. and Biol. Survey, Publ. 32 (1922), p. 106.

[2] Robinson, W. I., *National Petroleum News*, Sept. 6, 1922.

igan area. If the general trend of folding were parallel to the regional dip, it would be only logical to assume that drainage would take place by up-dip migration. In this way the structures might act as a favorable trap for temporary accumulation, but they would also furnish a channel of escape to the outcrop or adjacent regions.

All these early ideas were decidedly discouraging for oil exploration and the possibility of any large output seemed very meager. Michigan certainly had excellent source rocks; the reservoir bodies were present, but any large effective barrier to migration was considered lacking.

MODIFICATIONS INTRODUCED BY RECENT DEVELOPMENT

Several modifications to previous notions have been introduced by recent development. Intensive drilling campaigns have begun to show that we must change or at least modify some of the previous current notions. At the present time considerable is known about one structure at Saginaw which is a mile wide, three miles long, and has a closure of about forty feet. Over three hundred wells have given this information of a very limited area and other scattered drilling has more or less outlined conditions in other districts. Certain general deductions which pertain to size and characteristics of structures may be arrived at from these findings.

The size of many Michigan local structures is much larger than heretofore supposed, and minor structures have been found to link up together so as to approach major magnitude. Already the length of one structure is known to be from 80 to 100 miles and to extend across four counties. The width of this will probably vary from 4 to 10 miles, but these dimensions are by no means accurate. Such a fold, although not characterized by high dips, has important significance for its size. There is further evidence that large-sized folds extend into the center of the basin. A successful well drilled on the basis of a structure outlined from confidential data of the Dow Chemical Company has just recently been completed in the western part of Midland County. To judge from the depths penetrated, this location is only a few miles from the exact center of the structural basin. Some have gone so far as to join lines of

disturbance south of Port Huron, at Saginaw, near Mt. Pleasant, and south of Manistee, and have assigned them structural connection across the state. Although this type of thing will undoubtedly be found to be possible where future drilling warrants it, for the present the gaps are altogether too wide and the wells too far apart. The joining of local structures which seem to have alignment entirely across the state should have further basis in fact.

From the data accumulated on Michigan structures, they seem to have certain characteristics in common. There is a tendency toward elongation and the known folds have narrowness in comparison with length. The trend toward the center of the basin is common and they generally plunge in that direction. The structure carries down with depth below the Pennsylvanian, as no large structural disturbance is involved in the unconformable relationships below until the slight folding in the Monroe is reached. Structure is accentuated at depth and thickening is present on the flanks of anticlines, as would be expected. High points of structure seem to be shifted toward the center of the basin with depth. All the known folds appear to be asymmetrical with the steep dip toward the basin side.

LOCATION OF RECENT WELLS ON STRUCTURE

Since the Saginaw Oil Field showed such a close correspondence of production and structure, greater effort has been made to locate wells on possible structurally high points. The tendency has been to assume a trend of the crest of an individual structure and to locate the wells along the direction of this supposed trend. However, with the wide spacing in "wildcat" territory, several dry holes located in this manner show very little about exact structure. If wells are not staggered on supposed structure, the only possible way to delineate the folding is by shallow tests. One large company operating in Michigan has adopted this procedure and results should be forthcoming in another year.

Drilling has been extensive enough in certain districts to give the structures somewhat of a major testing. The difficulty has been to show the exactness of location on structure, and dry holes, though discouraging, have not disproved the possibilities. Those

structures revealed more clearly are the ones south and southeast of Saginaw; the Ann Arbor, Howell, Owosso anticline; and the fold north of Muskegon. Much is yet to be learned about these structures, but they are at least in part outlined so as to act as a guide for future prospecting.

Recently many other "wildcat" wells have been drilled in scattered localities throughout the state. Most of these have been located as close on structure as information would permit, but they have been fostered largely by promotion enterprises. They have contributed considerably to correct areal geology, give thickness variation, show local formation conditions, and ascertain points of control on structure.

LOCAL STRUCTURAL FEATURES IMPORTANT FOR ACCUMULATION

In view of the present knowledge concerning the structural features of the Michigan Basin there are local changes that should have considerable effect on accumulation. Local porosity conditions will certainly exercise a controlling effect and the coral reef character of the Traverse limestone will determine a great deal of the production in that formation. The type of folding that should be regarded as having high possibilities is that which is parallel to the regional strike or at a very small angle to the strike. Back dip or terrace effects coming up the regional dip from the center of the basin will probably be found to be of major importance in productive areas. Structural nosing with closure like the Saginaw Anticline will undoubtedly be the most significant type of fold to warrant testing, and many more should exist of similar character.

POSSIBLE NEW LINES OF STRUCTURAL INFLUENCE

In addition to the numerous radial structures due to vertical forces in the depositional settling of the basin, which no doubt exist, it is entirely possible that the more pronounced structures have had additional causes entering into their formation. Possibilities which at once suggest themselves are adjacent major structural features, deeply buried granitic masses, deep-seated faulting, and glacial load effects. Some of the factors have been previously suggested, but not particularly amplified as of any significance.

The causes of structure in northwestern Ohio and southwestern Ontario are closely connected with the Cincinnati Arch. It should consequently be expected that some dying-out effects from this feature should make themselves felt in the southern and southeastern parts of the Michigan Basin. Some of the structural disturbances in Michigan trend from across Canada and one seems to link very closely with Carmen's "drop off" which he has traced through western Ohio as far north as the Michigan boundary.

Another structural feature which manifests its presence in one form or another throughout a large part of Paleozoic history is the supposed land mass of Kankakeeia, which was one of Schuchert's positive elements. Some of the structural disturbances in southwestern Michigan could well be affiliated with this conception. According to the idea that Kankakeeia had a northeast-southwest directional trend, it would serve as a buttress for forces acting toward it, and would cause folding parallel to its alignment. In a general way the known arch which extends from the vicinity of South Bend northeastward and crosses Cass County, Michigan, a little east of Niles might have been somewhat controlled in its origin by the presence of this land mass.

The LaSalle Anticline in Illinois is another broad structural arch, and although the forces which produced this feature probably did not have any large direct effect on Michigan structure, its proximity is sufficient to merit attention. It does not seem logical to assume that such an extensive structural upwarping could take place without having some effect on adjoining regions.

Major structural features, such as the Cincinnati Arch, the land mass of Kankakeeia, and the LaSalle Anticline, must have had some effect upon the folding in the Michigan Basin. It is quite possible that many of the small structures radial to the basin due to vertical forces acted as rudders to localize pressure from major movements. These pressures were probably greatly dampened when they reached any distance into the center of the basin, but the forces must have caused some of the wrinkling which now exists in the rocks of the state.

The fact that pre-Cambrian masses exist at the surface in the adjoining state of Wisconsin, to the northeast in Canada, and in

the Northern Peninsula of Michigan would suggest a possibility of buried ridges extending under the Southern Peninsula. Since extensive peneplanation of the basement rocks is known to have taken place, ridges were probably never developed as in eastern Kansas, but the chance nevertheless is present that something of this kind exists. The close proximity of the "Wisconsin Island" is a factor that should not be neglected in any consideration of Michigan structure.

Deep-seated faulting has been used to explain many peculiar types of folds, and the narrow elongation and asymmetrical shape of most of the known structures in the state are quite evident. Faults of large displacement have not been observed in the surface rocks, but several showing movement of from 50 to 100 feet are known. Among the possible causes of local deep-seated faulting are submarine creep at the time of deposition, ablation of the salt beds, and gypsum-anhydrite reactions. Actual supporting facts to prove the presence of large faulted conditions at depth are very meager, and much future drilling will be necessary to sustain such a theory.

The location of southern Michigan in the avenue of glacial ice retreat may have a significant bearing on structure. Studies of old lake beach levels have already shown the general northward tilting upward which resulted from the relief of load. The fact that the basins of Lake Michigan, Lake Huron, and Saginaw Bay were the location of glacial ice lobes at the time of retreat is important in consideration of local structure. Many would argue that glacial effects would not be likely to extend to any depth, and this is no doubt true. Structural control of the direction of ice movement and the load involved in a body of ice as thick as the continental glacier cannot, however, be dismissed as unimportant factors.

SUMMARY

Both the realization of the importance of existing structural features in Michigan and the possibility of new influences heretofore unrecognized have controlled recent oil development in the state to a large extent. Those characteristics of the Michigan

Basin which loomed up to condemn the state as an oil producer have been found not so potent as previously considered. The drill will constantly throw new light upon the conditions of structure and aid to prove or disprove present hypotheses. In brief, the structural influences on Michigan oil development may be summarized:

(1) There is a close relationshp between oil accumulation and structure in the Michigan Basin.

(2) Structures are present which actually do contain pools of commercial oil.

(3) The size of the structures is much larger than heretofore considered and they trend into the center of the basin. Some folding may go entirely across the state in continuous lines of structural disturbance.

(4) So much is still unknown about actual conditions of structure that many possibilities suggest themselves for testing.

(5) Even if outside structural influences did not enter into the formation of folds in the Michigan Basin as contended, still, according to the postulated origin from vertical forces involved in stress relations of depositional settling, a number of simple and not unlikely conditions of structure would permit considerable local concentration of oil. Closed anticlines, terraces or bench structures, and folds with their axes at an angle to the regional dip should offer favorable places for pools of petroleum to occur.

State Geological Survey
Lansing, Michigan

THE ORIGIN OF PEARL HARBOR, ISLAND OF OAHU*

JAMES B. POLLOCK

INTRODUCTION

CERTAIN writers on the geography and geology of Oahu have asserted that Pearl Harbor is a series of eroded, dendritic valleys of a simple type. Professor W. M. Davis[1] writes of it that "the elevated reef (on Oahu) is broadest along the western part of the southern coast and here it is entered by the branching 'lochs' of Pearl Harbor which are neither more nor less than drowned valleys of the most normal kind." Doctor J. C. Branner,[2] writing of the origin of Pearl Harbor, says: "Briefly, this harbor has been formed by the depression beneath the sea of a small group of dendritic valleys previously carved by subaerial erosion in horizontal beds of rocks." Both Davis and Branner, therefore, consider Pearl Harbor as a series of dendritic valleys formed by subaërial erosion and drowned by the subsidence of the island.

During a sojourn of two years (1922–24) on Oahu the writer made an intensive study of coral reefs, both fossil and living, around the island. In this study many observations about Pearl Harbor convinced him that its interpretation as a series of dendritic valleys formed by subaërial erosion was not the correct one. The evidence for a less simple interpretation is here presented.

THE ORIGINAL PEARL HARBOR BAY

The origin of Pearl Harbor is of course connected with the origin of the island of Oahu as a whole. This island is basically of

* Paper No. 279 from the Department of Botany, University of Michigan.

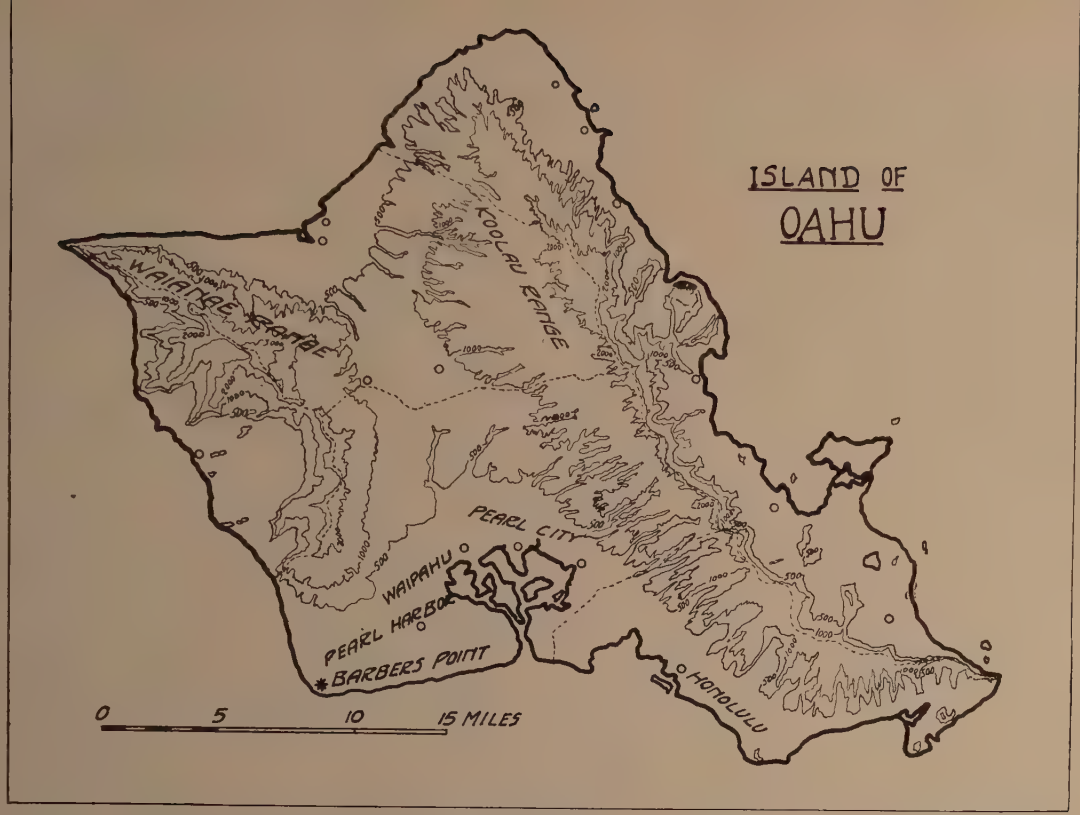
[1] Davis, W. M., "A Shaler Memorial Study of Coral Reefs," *Am. Journ. Sci.*, 4th ser., 40 (1915): 223–271. See p. 249.

[2] Branner, J. C., "Notes on the Geology of the Hawaiian Islands," *Am. Journ. Sci.*, 4th ser., 16 (1903): 301–316. See p. 303.

volcanic origin and geologists are agreed that it is a doublet. Two distinct centers of volcanic action first built up two separate islands, and these were later united by outpouring of lava from one of them which filled up the area between, raising it above sea-level. One of these centers of volcanic activity is the Waianae mountain range which borders the western side of the island. The other is the Koolau range farther to the northeast, and extending much farther southeastward than does the Waianae range. The highest crests of these two ranges are about fourteen miles apart at their closest proximity. When the latest outpouring of lava from the Koolau range built up the land between the two ranges, a broad open bay was left between the southeast end of the Waianae range and the greater southeastern extension of the other range (see map of the island, Map 11). The western side of the mouth of this bay lay at the southeastern foot of the Waianae range. The mouth of the bay on the eastern side was bounded by the slopes of the Koolau range and must have been located not far from Moanalua a few miles west of the city of Honolulu. The remnants of volcanic cones known as Twin Peaks, and the series of craters in the bottom of one of which is a small body of water known as Salt Lake, are now located near what was originally the eastern side of the broad bay. If this bay originated before the tuff cones of the Salt Lake region, as in all probability it did, the distance across its mouth at first must have been as much as eight miles, measured at present sea-level. Taking as a pivotal point the foot of Waipio Peninsula, in this paper called Waipio Point, where all the outlets of the different lochs meet, the radii of the lochs, measured from this point in five directions to the mainland shore, vary from about three and one half to four miles.

THE DEPTH OF THE ORIGINAL BAY

It seems possible to determine the depth of the original bay at least within certain wide limits of approximation. One of the striking features in the landscape in the vicinity of Pearl Harbor is a small, more or less roughly triangular area on the surface of each downward-sloping intervalley spur of the Koolau range, which stands out as quite different from the rest of the topography. These



MAP 11. Outline map of Oahu, with a few contour lines to show the elevations. The 500-foot contour line gives an idea of the original shape of Pearl Harbor, but not of its size. The higher ones indicate the two original mountain ranges

areas are visible not only in the region of Pearl Harbor but also eastward to Honolulu and beyond where all the broader spurs show such areas. Wentworth[3] has called these triangular patches "flow slope facets" and considers that they are "remnants of the original flow slope of the Koolau cone," and that they "show essentially the same degree of slope as the underlying lava flows." On the lower slopes of this side of the Koolau range the rainfall is only about 20 to 30 inches per annum and near the seashore even less than that, while on the higher slopes of the range it may be 100 inches or more; hence at the higher levels the erosion of the intervalley spurs has lowered the original surface very considerably and changed the inclination. On the flow slope facets themselves the local rainfall has not modified the inclination nor the altitude to any great degree. The Waianae range is more distant from Pearl Harbor than the Koolau, and the former is separated from the harbor by a broad, gently sloping plain which is in considerable part the product of a much longer period of erosion of the Waianae range, conceded to be older than the Koolau. The slopes from the Waianae range therefore have been so much changed from their original inclination that they cannot serve as a guide to the original depth of the bay. On the eastern side of Pearl Harbor the relatively recent eruptions from the Salt Lake Crater have partially filled the original Pearl Harbor Bay, and have built up shores of volcanic tuff. To the westward the slope around the shore has been modified by deposition of materials eroded from the Waianae range and from the plateau between the ranges.

There is evidence that the island of Oahu in former times has been submerged to two or more levels higher than present sea-level, one of about 20 feet, another of 40, one at 80 and possibly one at 250.[4] Wentworth[5] believes that at a stand of the sea 40 feet higher than at present, sea-cliffs were cut at the front of the Koolau spurs with a height at the top of about 200 feet above present sea-level. The modifications of shore-line at these various sea-levels make it

[3] Wentworth, C. K., *Pyroclastic Geology of Oahu*, Bull. 30. Bernice P. Bishop Museum, Honolulu, 1926. (See p. 9.)

[4] Pollock, J. B., *Fringing and Fossil Coral Reefs on Oahu.* Bernice P. Bishop Museum, Honolulu. Bull. 55. 1928.

[5] Wentworth, C. K., *op. cit.*, p. 120.

inadvisable to use the slope up to 250 feet as a basis for the measurement.

It is clear that only the flow slope facets on the spurs of the Koolau range show approximately the original slope and surface of the island, and that the inclination indicated by the contour lines from 1000 or 1500 feet to 500 feet on those spurs will furnish the best basis for determining the depth of the original bay at Waipio Point, which will also be the minimum depth of marine deposits at this locality.

To make the desired determination five lines were measured on the topographic map, along the spurs of the Koolau range, between contour lines of 1500 and 500 feet altitude. The slope of these was projected to Waipio Point and the depth calculated by proportion. Of these five lines the minimum depth found along single lines was 1090 feet, the maximum was 1988 feet, and the average was 1549 feet. If shorter lines were used for projection the average result was not very different, though the range for individual lines was different. When the slope from 1500 to 1000 feet was the basis of the projection, the range was 418 to 2263 feet, but the average was 1536 feet. If the slope between 1000 and 500 feet was used for projection, the range was 1134 to 2236 feet, and the average was 1506 feet. If the slope of the Waianae range from 1500 to 500 feet is taken as the basis of projection, the indicated depth of the projected lines is between 3000 and 4000 feet below present sea-level at Waipio Point. Since, in this region at least, the original depth of the bay at Waipio Point cannot have been less than about 1500 feet below present sea-level, the bottom at Waipio Point has never been above sea-level, even though the island of Oahu once stood 1000 feet higher than it does now, as is asserted by Palmer.[6] In his study of records of artesian wells in the region of Honolulu, he has shown that the basal lavas underlying "coral" rock, found in the wells drilled in the Honolulu region and the valleys eroded in those lavas, were about 1000 feet below present sea-level within the present shore-line of the island. If similar ancient valleys were

[6] Palmer, H. S., *The Geology of the Honolulu Artesian Basin.* Supplement to the report of the Honolulu Sewer and Water Commission to the Legislature of the Territory of Hawaii. Honolulu, 1927.

present in the vicinity of Pearl Harbor there is no reason to suppose they had any different relation to present shore-line and sea-level.

The facts warrant the following conclusions as to the depth of the broad bay in which Pearl Harbor developed:

1. At Waipio Point the bottom could not have been less than 1500 feet below present sea-level, and may have been considerably lower.

2. The surface of the flow slope facets, if projected toward Waipio Point, falls below present sea-level before reaching the shore-line of Pearl Harbor; hence, no erosion valleys in the original Koolau lava flows nor any remnants of ridges between such valleys could appear in the land forms now visible in the harbor.

3. The materials that filled the broad bay and made the present harbor were deposited beneath the sea, except those that were built up above sea-level by local volcanic eruptions.

THE ISLANDS AND PENINSULAS

On the topography of Pearl Harbor Branner writes:[7] "We shall readily understand the process by which this topography was made if we imagine the whole island elevated fifty or seventy-five feet and the original rock beds restored right across the present channels. We should then have the streams that now enter the upper parts of Pearl Harbor flowing across a table land of horizontal rocks, uniting at or near the point marked A on the map [Waipio Point] and entering the sea below the boat landing through a single channel. In the course of time these streams would all cut steep-sided gorges, and where the gorges, by bends in the streams, approached each other the watershed between the two streams would be lowered below the general land surface. Such a place would eventually be a bit of high land and after depression would form an island, such as we have in Mokuumeume. A depression of the island would back the sea into the valleys; the cutting of the streams would then cease, and land silts would settle in the quiet waters of the submerged channels, forming shallows, later mud flats, and then the swamplands."

Branner's interpretation assumes that Pearl Harbor was at

[7] Branner, J. C., Pl. 15 of paper cited in note 2.

some past time completely filled by submarine and volcanic deposits to a former, higher sea-level, and that the islands and peninsulas are the remnants of ridges between the gorge-like valleys in these deposits. It is a logical inference, then, that these islands and peninsulas should be so situated as to be considered extensions of the ridges between the fresh-water streams from the mainland, that their topography should conform to that of ridges between gorge-like valleys, and that the channels of the harbor should be so situated as to be continuations of the fresh-water streams. None of these implications is in agreement with conditions as they actually exist. Kuahua, or Magazine Island, is the only one that could be considered such an extension, and that it is not such an extension will be shown later.

FORD ISLAND

Ford Island is the largest island in Pearl Harbor (Branner's Mokuumeume is its native name). It was studied by traversing about three fourths of its shore-line on foot, and by observations in an oil-pipe trench running nearly the full length of the island on the southeast side, and varying from about one and one-half to twelve feet deep. The observations were recorded in a field note-book as made.

The materials composing Ford Island are of three kinds: calcium carbonate, the product of living organisms, both animal and plant; volcanic tuff in definite strata, a product of eruptions in the group of Salt Lake craters; and a clay-like earth varying from a distinctly reddish to a very dark color.

The calcium carbonate is in some places in the form of thin strata of calcareous rock composed of sand, fragments of coral, some shells and other kinds of animal remains, sloping gently downward toward the shore. These materials were evidently deposited beneath the sea. Shore cliffs composed of this kind of rock were seen on the westerly part of the northwest shore, along Middle Channel. Most of the calcareous rocks exposed in the shore cliff were not in such definite strata, and were composed to a larger extent of coral, some of which was in position as if in place where it grew and other portions of which were obviously wave-washed frag-

ments. Of that which appeared to have grown in place there was a considerable amount composed of slender vertical branches, often anastomosing, but also sometimes rather widely separated and surrounded by the clay-like earth, or by sand, that filled in the spaces between the branches. These slender, vertical branches have been called "finger coral." Another type of coral structure, seen both in the shore cliffs and in considerable quantities in materials dredged from the channels in recent dredging operations, was composed of thin layers of coral overlying one another. These layers of coral are often in a horizontal position, but sometimes are convex, or dome-shaped. This has been called "superposed coral." This type is more or less abundant wherever materials dredged from the channels were available for observation, as was the case in several places in the harbor. Other forms of coral, branching in various ways, were present, and may be referred to as "branching corals." No attempts were made in the observation about Ford Island to distinguish the calcareous materials derived from plants, but on the shore of Waipio Peninsula opposite Ford Island quantities of coralline algae were seen growing along the shore, in the form of rounded nodules that were readily rolled about by the waves, and were so brittle that they were easily disintegrated into fragments and ground by wave action into a fine, sandy, grayish marl.[8] They undoubtedly contribute material to form calcareous sand of all grades of fineness.

While most of the shore observed was composed of calcareous materials, at various localities on the southeast side of Ford Island strata of volcanic tuff composed the shore cliffs wholly or in part. This region is opposite that portion of the eastern shore of Pearl Harbor which is formed mainly of the tuff thrown out by explosive eruptions from the Salt Lake Crater and carried to this region by the trade winds that blow strongly from northeast to southwest during most of the year. This wind-drifted tuff forms a broad, gently sloping ridge from those craters to the main outlet channel of Pearl Harbor. The strata of tuff observed on Ford Island are undoubtedly of the same origin. The lowest ones observed at low tide were the thickest, some being six inches or more thick. They

[8] Pollock, J. B., as cited in note 4.

gradually became thinner toward the top; the highest ones were not more than one or two inches in thickness and were frequently separated from one another by seams of calcareous material slightly consolidated into a soft lime rock. This was probably formed chiefly if not wholly of calcareous sand deposited under water in the intervals between the later eruptions from the Salt Lake Crater. The conditions described are exactly similar to those observed on the other side of the channel near the coal dock, where the broad, gently sloping ridge from the Salt Lake craters reaches the channel. On both sides of this channel, that is, on Ford Island and on the eastern mainland shore, the highest layers of tuff are covered by calcareous deposits containing easily recognizable coral fragments. While along the mainland shore on the eastern side of the channel the tuff layers may be followed continuously under the calcareous rock, on Ford Island these tuff layers are not continuous on this side of the island from water level up, but a considerable part of this shore was built up wholly of calcareous materials with recognizable coral among them. No such tuff strata were observed on the northwestern side of Ford Island along the central channel.

In the large oil-pipe trench both the tuff layers and calcareous materials were observed, usually with thin sheets of the latter between the upper strata of the former, as along the shore. In a considerable part of the trench, however, no tuff strata were observed. In some of these places calcareous material showed from the bottom to the top of the trench, but in many places the calcareous materials alternated with the reddish or dark-colored clay-like earth. In certain places the calcareous material was in the form of slender vertical branches of finger coral. Often no coral structure could be recognized in these branches, but in a few places the typical coral structure was recognized with the aid of a hand lens. The slender vertical branches were, therefore, interpreted as being composed of coral, even when that structure could not be recognized. They were sometimes very close together, one to several inches, but sometimes farther apart, a foot or more. Between them was the clay-like earth, which also formed the surface layers of soil in which, during former years, before Ford Island became part of the Navy reservation, crops of sugar cane had been

grown. In numerous places, however, patches of calcareous rock appear at the surface of this soil, even on the highest part of the island, which is at an altitude of 40 feet as indicated on a contour map with 40-foot intervals between contour lines (Map 12). The highest part of the island is near the northeastern end and, while the southeastern shore varies in height from 2 or 3 feet up to 10 or 12 feet, most of it is not over 5 to 8 feet above low water. At the most northerly corner of the island, however, the shore cliff rises to about 16 feet in height and around the corner on the northwest side it was estimated to be as high as 20 feet. At the northeastern end, where it was about 16 feet high, as determined partly by measurement and partly by estimate, it was all calcareous with much recognizable coral, except for a stratum of tuff varying from 10 to 16 inches in thickness. This tuff stratum consisted of alternating sheets of tuff with thin calcareous seams, and as a whole was interbedded with masses of calcareous rock both above and below it. The highest level at which this tuff layer was seen in this exposure was at about 8 feet above low water, and it had, therefore, 7 or 8 feet of calcareous rock overlying it. Farther toward the northwest it dipped downward in the calcareous exposure so that it came to lie only 2 to 4 feet above low water. This same tuff layer or one like it in thickness, composition, and relation to calcareous rock, was seen on Waipio Peninsula, almost directly across Middle Channel from this part of Ford Island.

In the oil-pipe trench on Ford Island at various places the sides of the trench showed considerable amounts of the dark or reddish earth mentioned before, which sometimes surrounded the vertical branches of finger coral, or covered this or other kinds of calcareous rock. The materials composing this clay-like earth may have been derived from either or both of two different sources. On the one hand it may have had its origin in the decay of tuff layers such as have already been described and which originated from the Salt Lake craters. Such modification of tuff layers into a dark or reddish clay-like earth, in which no evidence of stratification could be recognized, was observed elsewhere in tuff deposits around the Makalapa Crater, where there was no doubt that the clay-like soil originated from the decay of volcanic tuff composed generally of

Map 12. Pearl Harbor and vicinity, with the Salt Lake Crater region. The contour lines are at 40-foot intervals, and thus show the high points on Ford Island and Waipio Peninsula. The "flow slope facets" may be recognized on the Koolau spurs. The broad ridge of wind-drifted tuff is indicated by curved southwestward salients of the contour lines to the southwest of Salt Lake craters

particles of a size called lapilli. It seems very likely that much of the similar deposits on Ford Island had a similar origin but, since they were farther from the point of eruption, only the finer ash was carried by the wind as far as Ford Island. On the other hand, since these are submarine deposits, such earthy material may have originated in silt brought down by erosion of the mainland by tropical storms. In one of such storms referred to, about thirty inches of water fell in three days and the mud and silt brought down from the highlands discolored the ocean all around the island out to the coral reef and beyond. It was several weeks before the ocean water around the shores regained its usual clearness. The vertical branches of finger coral surrounded by the clay, as they were seen in the trench, must have been able to continue their growth upward while the material composing the earth was deposited around them, whether its origin was from the tuff of the Salt Lake craters or from the mud and silt formed by the decay of older lava rock on the surrounding mainland. There was a sufficient amount of this clay soil to furnish the substratum for the growth of sugar cane on Ford Island, but in cultivation of the soil the plow must frequently have turned up fragments of coral that were not too massive to resist the impact. Some such fragments turned up by the plow in a cane field were seen on that part of Waipio Peninsula across Middle Channel from Ford Island, at an altitude of almost 40 feet.

In summary it may be said that Ford Island is wholly a product of submarine deposition, that its calcareous materials have originated from corals and other lime-secreting animals, and probably in part from lime-secreting plants. Its tuff layers were derived by explosive eruptions from the Salt Lake Crater region which drifted on the wind to the southwest and were deposited in the sea water that filled the harbor. The soil or other earthy material surrounding or covering the calcareous deposits has probably come chiefly from the decay of volcanic tuff, but may have been added to substantially by silt brought down in floods from the surrounding mainland.

It has been noted that the highest point of Ford Island is near the northeastern end and is at an altitude of 40 feet (Map 12).

From this high point there is a gentle slope toward the southwestern end of the island where the shore cliffs are mostly about 5 to 6 feet above low water. The shore on the southeastern side varies from 2 or 3 feet to 10 or 12 feet above low water, while on the northwestern side along Middle Channel it will average a number of feet lower, and only as one approaches the northern corner does it rise rather suddenly to an altitude estimated at 20 feet. The surface topography is not at all such as would be expected if, as Branner implied, the islands and peninsulas of Pearl Harbor are remnants of a "table land" left between "gorge-like valleys" formed by subaërial erosion. The general slope and altitude of the island from the 40-foot altitude near the northeastern end to the 5- or 6-foot altitude at the southwestern end conform substantially to those of the seaward portion of the coral plain that covers all the coastal area of Oahu from Pearl Harbor to Barbers Point. Its surface conforms to the effects of submarine rather than to those of subaërial agencies.

There is no evidence that Ford Island is part of a ridge that once extended to the mainland between adjacent streams. If it were, this ridge should have been eroded from the mouth toward the head of the streams instead of from the head toward the mouth. The island is about one mile from the mainland, and is only about one and one-quarter miles in length, and one-half mile in width.

The latest change of strand line on Oahu brought it to its present position from a stand about 20 feet higher on the land than the present one, and this change probably took place about 5000 years ago.[9–10] Wentworth's work[11] indicates that a stand of 40 feet immediately preceded that at 20. Hence the last two changes in the relative positions of land and sea were emergences of the land, and not submergences. Since the highest calcareous rocks on Ford Island are at an altitude of about 40 feet above present sea-level,

[9] Wentworth, C. K., and Palmer, H. S., "Eustatic Bench of Islands of the North Pacific," *Bull. Geol. Soc. Am.*, 36 (Sept., 1925): 521–544.

[10] Pollock, J. B., "The Amount of the Geologically Recent Negative Shift of Strand Line on Oahu," *Journ. Wash. Acad. Sci.*, 18 (1928, No. 3): 53–59.

[11] Wentworth, C. K., p. 119 of bulletin cited in note 3; also Pollock, J. B., as cited in note 4.

in all probability they were deposited when the sea stood at that level or only slightly higher. No higher calcareous deposits were seen anywhere in Pearl Harbor. As at present sea-level, so at former ones the tidal currents have moved in and out of Pearl Harbor tending to keep open channels by tidal action alone. In addition to this action the fresh-water streams that flow into Pearl Harbor, of which there are several of considerable size for the region, bring sufficient fresh water to interfere with the growth of corals and other marine organisms in the vicinity of their outlets. This has had the effect of keeping open bays all along the inner border of the harbor, in spite of the deposition of erosional materials brought down by the rivers or formed by wave action.

The fact that nearly horizontal layers of tuff occur both on Ford Island and on the mainland shore opposite does not by itself furnish proof that the channel between them was wholly eroded in such horizontal layers. Evidence has been presented that these layers have been deposited from the air as wind-drifted ash and have fallen into the sea in quantities sufficient to form strata only 1 or 2 to 6 inches thick at any one time for those exposed in the shore cliffs on Ford Island, and that the intervals between the time of deposit of these strata allowed calcareous materials to collect. After each such stratum was deposited in the line of the tidal currents the flow would be sufficient to remove almost at once the rather finely divided tufaceous material of which the deposits were composed, so that a channel could be kept open continuously in time and yet allow these strata to build up deposits such as are now visible along the quieter margins of channels. Thus it is not necessary to assume, as Branner did, that only subaërial erosion through horizontal strata raised above sea-level could produce the channels. The channels may have been produced by tidal currents and kept open while their margins were building up below sea-level.

At the present time wave erosion is modifying the shore-line and to some extent has shaped the vertical shore cliffs. At the northeastern end of Ford Island, where the waves produced by the almost continuous strong trade wind beat with their greatest intensity, a former extension of the island to the northeast for

several hundred yards has been eroded, leaving as remnants a shoal upon which appear a few small islands composed only of calcareous material. It is this erosion by the waves stirred up by the trade winds that has produced the higher shore cliffs at this end of the island.

THE PENINSULAS

Not only is Ford Island the product of marine agencies as regards both its topography and its shape, but this statement is equally true for both of the peninsulas that project into Pearl Harbor from the present mainland shore. Neither of them is a continuation of any mainland ridge. Both are separated from the adjacent mainland by a strip of land lying only a few feet above sea-level, probably not over 5 feet, in which rice culture is now carried on. The width of this low ground from Waipahu toward Waipio Peninsula is seven tenths of a mile as measured by an auto speedometer. The similar strip of rice land that separates Pearl City Peninsula from the adjacent shore is perhaps not quite so wide. The higher part of the latter peninsula is probably not over 15 feet above sea-level at its highest point and would certainly be completely submerged at a sea-level 20 feet higher than the present.

On the topographic map with 40-foot intervals between the contour lines three points on Waipio Peninsula are seen to have an altitude of 40 feet (Map 12). One of these points is on that region of the peninsula nearest Ford Island, from which it is separated by Middle Channel. The two other points on the peninsula that have an altitude of 40 feet are toward the western side. One of them is at the top of a very sudden rise in land which comes after one has crossed the low area near Waipahu. Between the point first mentioned with an altitude of 40 feet on the peninsula and the other two, there is a broad shallow depression crossing the peninsula diagonally, running nearly from northeast to southwest and only a few feet above sea-level. Near the center of this depression is a body of water known as Loko Hanaloa. It was estimated that a 10-foot rise of water here would completely cross the peninsula and separate it into two portions, and would also cover

the low portion of the peninsula near Waipahu and convert it into two islands. The depression across the peninsula is not in line with any of the fresh-water streams from the mainland, nor is it in the direction of any of the main channels that serve as outlets to the sea from Pearl Harbor. It is impossible to interpret it as a product of subaërial erosion. From the high points on Waipio Peninsula at an altitude of 40 feet the surface slopes quite gently down to the central depression, though on the eastern side of Loko Hanaloa there is an outcrop of calcareous rock which, while lying in a position nearly horizontal, seems to be more or less crumpled into wave-like folds. On one of the slopes near the base of this depression the soil was seen to be composed to a considerable extent of the grayish marl mentioned before, which is a product of the decomposition of a nodular, lime-secreting, red alga. The seaward part of the peninsula has a structure, as revealed by a traverse of the shore cliff on both sides of Waipio Point, similar to that of the seaward end of Ford Island. The tuff strata and calcareous rock containing coral have a similar relation on both the peninsula and the island. Less of the shore on the peninsula showed the tuff layers, however, and those showed only near the seaward extremity of the peninsula except that a layer of tuff 10 to 16 inches thick and similar to that at the northeast end of Ford Island was found in a corresponding position on the peninsula, bedded between calcareous rock above and below it. The peninsula is farther from the source of the wind-drifted ash than is Ford Island. In a cane field near the 40-foot altitude on the seaward part of the peninsula coral fragments were observed where they had evidently been turned up by the plow in preparation of the land for the growth of sugar cane. All the observations made here indicate that this more seaward portion of Waipio Peninsula has exactly the same structure as has been described for Ford Island, composed of the tuff layers, calcareous rock and the clay-like soil, combined and distributed in practically the same way in both the island and the adjacent part of the peninsula.

The part of the peninsula west of the central depression was not observed in as much detail and its exact interpretation is less certain. What is certain, however, is that Waipio Peninsula can no

must be interpreted as a remnant of a ridge between valleys formed by subaerial erosion than can Ford Island.

Little need be said about Pearl City Peninsula. It has been pointed out that the seaward portion of it, which now lies above present sea-level and culminates at not more than 15 feet, is somewhat higher than the neck of the peninsula which joins it to the mainland. In this respect it is like Waipio Peninsula, the necks of both being the seat of rice culture and lying very little above sea-level, probably not over 5 feet. These two necks are in all probability composed of the silt washed down by the streams from the surrounding mainlands and one of the larger of the streams of this region has its mouth beside the neck of each of the peninsulas. Indeed, it seems not unlikely that without the silt brought by each of these streams to relatively recent times both the peninsulas would be separated from their surrounding mainland shores by a strip of water half a mile wide or less. Neither of the peninsulas, then, offers any support to the interpretation of Pearl Harbor as the product of subaerial erosion.

Ford Island

Ford Island in the eastern part of Pearl Harbor requires a different interpretation from that of Pearl Island. The former island and the channel which separates it from the eastern shore appear to owe more than any other feature in Pearl Harbor to conformity with the statement of Dr. Branner that the channels have been eroded in horizontal strata, yet that interpretation is as erroneous for the channel that separates this island from the eastern mainland shore as for the features already discussed.

All the shore on this side of the harbor is different from the shore on the other parts of its circumference. It is composed to a very predominant degree of the tuff thrown from the group of the Salt Lake craters. The last eruption in this region was only a few hundred yards from the eastern shore of the harbor, at Makalapa Crater. The mainland shore opposite Ford Island shows a nearly vertical exposure of the tuff, having an altitude at the top of at least 20 feet. The strata of this tuff are nearly horizontal. Sentinels on guard would not allow an inspection of the upper

site shore of Kuahua Island, but from across the channel the island seemed to be composed of the same kind of tuff strata with about the same altitude at the top. It seems likely, therefore, that at some time in the past the tuff strata were continuous across the channel from the mainland to Kuahua Island. Though this be granted as a fact, other facts make it impossible that this channel could have been formed by erosion, either subaërial or marine. The first of these facts to be noted is that, though the tuff strata may have been continuous from the mainland to Kuahua Island, they were certainly not continued across the wider channel, East Channel, that separates this island from Ford Island, at least not above present sea-level. The exposed shore of Ford Island at the point opposite Kuahua is calcareous from low water level to the top, and not tufaceous. The second significant fact is that, while the two shores of the Kuahua Channel may have an altitude of about 20 feet, the adjacent shore of Ford Island is not more than 10 to 12 feet at its highest point, and has probably not been any higher than this since it was raised above sea-level. The third fact, the evidence for which will be presented later in the discussion of the channels in detail (see p. 243), is that the broad East Channel between Ford and Kuahua islands, even before the last shift of land or sea that established the present strand line, had a depth at its center that brought the bottom to about 16 feet below present sea-level. The fourth and last fact to be noted in this connection is that, at the time when the last eruption took place at Makalapa Crater, the sea stood about 20 feet higher on the land than it does now, as shown by the altitude of the wave-washed calcareous deposits capping the Makalapa tuffs.

The consideration of these four facts shows how entirely impossible it is that any water, either sea or fresh water, could have been impounded behind the tuffs that once blocked the channel between Kuahua Island and the eastern mainland shore, and raised to a level necessary to start the erosion of the tuffs at 20 feet above the present sea-level, when such waters had available, as outlets to the sea, channels whose bottoms at their centers, were not less than about 16 feet below the present and 36 feet below the former sea-level.

ORIGIN OF KUAHUA CHANNEL BY SUBSIDENCE

It may be asked, What, then, was the origin of this channel? It is well known that in regions near to craters in active eruption the eruptions are frequently accompanied by local subsidences and warping of the earth's strata. It seems most likely, therefore, that the channel referred to had its origin in such a subsidence, possibly at the time the Makalapa Crater burst its way through the older tuff deposits of the Salt Lake craters. Indeed there is some direct evidence for local subsidence in this region. On the southern shore of the southeastern loch the tuff strata exposed appear in places to sag and buckle instead of lying as nearly horizontal as they commonly do on the shore along the main channel. Slightly to the southwest of Makalapa Crater, and just beyond the head of Southeastern Loch, the engineers who built the oil-tanks for the Navy in 1923 and 1924 noted that, in preparing the foundations for the pumping station, they found tree molds in the tuff at a level which allowed the tide water to rise and fall in them. Similar tree molds were observed by the writer in the tank foundations around Makalapa Crater. Since sea-level stood 20 feet higher than at present when the Makalapa Crater was completed and the trees whose molds were seen must have grown above sea-level, it seems likely that the depression of the land at the head of Southeastern Loch has been formed, in part at least, by a local subsidence which could not have been less than 20 feet and may have been considerably more.

Other facts observed in this region furnish additional evidence for the interpretation of local subsidence. In connecting the different oil-tanks with pipe lines, trenches were dug here across one of the depressions and into the slopes on both sides of it and borings were made in it. From tank 38 a trench was followed down the slope several hundred feet. Along this slope the tuff layers exposed in the trench were not at all in a horizontal position or anywhere near it, but the individual strata had almost the same inclination as the general slope of the land, which was here rather steep, with a drop of 35 feet in 315 feet, or 1 in 9. The downward inclination was not in the direction outward from the center of

eruption at the Salt Lake craters, nor was it from Makalapa Crater. It was at right angles to a line from the former, and toward the latter. The depression at the bottom of this slope was certainly not eroded in horizontal strata. The inclination which these surface layers of tuff show may well have been because of a local subsidence either before or after the surface strata were deposited. In the bottom of the depression, as it shows at present, several borings by the oil-tank engineers showed coral materials down to some 40 feet below present sea-level. The depressions here, to the south and southeast of Makalapa Crater, do not have the appearance of having been shaped entirely by subaërial erosion. They do not branch out in a series of dendritic valleys. They are very broad in proportion to their length. They are in a very dry region and only the occasional tropical storms would have erosional force. The length of their drainage area is only to the rim of the Salt Lake craters and a straight line from the head of Southeast Loch to the high part of the rim of these craters is less than two miles. This depression is on one side of the broad, gently sloping ridge which extends from the Salt Lake craters to the Pearl Harbor main outlet channel and which was formed chiefly by the wind-drifted ash from the Salt Lake craters. If the local rainfall was sufficient to produce by erosion such broad, deep valleys as are found here on one side of the ridge, why are there no corresponding valleys on the other side of this ridge? Many observations in this region from different points of view seem to the writer to make it much more likely that the main features of the topography in the depressions between Makalapa Crater and the broad ridge are to a considerable degree the result of local subsidence rather than the result of subaërial erosion alone. It is granted that the latter process has modified them to some extent and is still at work shaping them.

A measure of the minimum amount of the local subsidence may be obtained by adding to the depth of coral in the borings across the depression 40 feet or more, the altitude of the site of oil-tank 38, which was 46 feet before the site was leveled for the foundation. It may be concluded, then, that the local subsidence was not less than 80 to 90 feet at this locality. The fact that the two latest changes in sea-level here relative to the land were in a direction of

an emergence of the land of a minimum of 40 feet makes it very unlikely that the coral down to 40 feet below present sea-level in the depression was deposited or grew on the bottom of a submerged valley that had been formed by subaërial erosion; but it is quite intelligible if the depression was formed by local subsidence, whether this took place when the strand line was at 20 or at 40 feet above the present one.

All the region on this side of Pearl Harbor is composed exclusively of the tuff from the Salt Lake craters, except where it is interbedded with or covered by calcareous deposits of marine origin. On this side of the harbor these calcareous deposits were seen nowhere higher than 25 feet above present sea-level, and the highest portions of them were of such materials as lie at the top of the beach above high water.[12] Where the broad ridge of the wind-drifted tuff shows along the shore of the main outlet channel, it is capped with calcareous rock containing easily recognizable coral and also has the thin seams of calcareous deposits between the upper tuff layers. These two facts prove that the shore here was below sea-level when the materials thrown out in the latest eruptions from the Salt Lake craters were carried over to this locality, and that this sea-level continued for some time after the eruptions had ceased in the Salt Lake Crater region, or at least, after they had ceased to drift as far as this locality from their point of origin.

When the Salt Lake craters built up their tuff cones they not only filled the eastern part of Pearl Harbor, but their deposits covered the lower part of the Koolau ridges in their vicinity and filled up the valleys of the adjacent streams from this range. Among the valleys partly filled was that of Halawa stream. Since this stream has its source in the higher regions where precipitation is heavy, its perpetual flow of fresh water overtopped the barrier placed in its path, and by subaërial erosion reëstablished the valley at its mouth, removing in the process part of the tuff deposits. The mouth of the valley was, however, deflected westward from its original course, and the stream now flows into the east side of East Loch. The influence of

[12] Pollock, J. B., p. 57 of first paper cited in note 10.

this erosion in shaping Pearl Harbor has been in filling in the bottom and building out the eastern shore of East Loch. It has had nothing to do directly with shaping the outlet channels from the lochs to the sea.

THE CHANNELS AND LOCHS OF PEARL HARBOR ARE NOT LIKE DENDRITIC VALLEYS

It is necessary to give some consideration to the channels and lochs of Pearl Harbor, since Davis and Branner interpreted them as dendritic valleys of the most normal kind. Davis has written numerous papers in which he emphasizes the importance of drowned dendritic valleys in the interpretation of Pacific islands. In a number of these papers he has figured such drowned valleys. A reference to one will be sufficient, since his figures show practically the same contours for them all.[13] Davis' figures show the effects of erosion on volcanic islands, but the subaërial erosion of raised sea bottom should not be essentially different. If one compares his diagrams with the outline of Pearl Harbor, a striking disagreement between the two may at once be noted. In the first place the embayed drowned valleys of his diagrams become narrower toward the head, where they are relatively sharp-pointed, and they are broadly open at the mouths, while the bays or lochs of Pearl Harbor become continuously broader toward the head, where they are exceedingly broad and pouch-like, and the channel outlet of each is decidedly narrower than the loch to which it is the outlet. Also each channel is broader at its head than it is at its mouth, except that the main channel broadens where it reaches the sea. Measurements were made on the map at several points across each of the channels and across each of the three larger lochs. (Figures given below in brackets indicate the number of measurements, of which the average is given.) The differences are very significant. The main channel, from Waipio Point to the sea, varies in width from 0.29 to 0.33 and has an average of 0.30 miles [5]. It is the only one that is wider at its mouth than at its head, where the other channels converge to form it. West Channel, from

[13] Davis, W. M., Figs. 1C, 2O, 3O, 5C, of paper cited in note 1.

West Loch to Waipio Point, varies from 0.20 to 0.40 with an average of 0.26 miles in width [15]. Its greatest width is where it leaves West Loch. West Loch itself is 1.66 miles across the inner bays [1]. Middle Channel, which lies between Ford Island and Waipio Peninsula and connects Middle Loch to the main channel, varies from 0.25 to 0.55 and averages 0.43 miles [5]. It also is widest at its head, where it leaves Middle Loch. It may serve as an outlet to East Loch, which thus has two outlets. Middle Loch varies from 0.44 to 0.81 with an average of 0.68 [6] and if the expansion of this loch, known as Loko Eo, is considered a part of the loch, as it properly should be since they are separated from each other by only a railway embankment, then Middle Loch near its head is 1.18 miles in width [1]. East Channel, between Ford Island on one side and a part of the mainland and Kuahua Island on the other, varies in width from 0.26 to 0.55 and averages 0.43 miles [4]. East Loch, which has both East and Middle channels to serve as its outlets, is 2.33 miles across [2 measurements of equal value].

These figures present quantitative data for the fact that is readily seen on inspection of the outline map of the harbor (Map 12), that the channels and the lochs are markedly different from drowned dendritic valleys. The channels of Pearl Harbor, instead of becoming wider at their mouths as is characteristic for dendritic valleys, have generally only minor variations in width for nearly their entire length, but each, with one exception, widens at its head instead of at its mouth. Only the main channel widens at its mouth, where it reaches the sea. Both Middle and East channels widen landward instead of seaward, and each of the two channels is wider in its narrowest region than that part of the main channel which carries their combined waters. The very great width of the lochs as compared with that of the channels which are their outlets, taken with the facts already presented as to the composition and topography of the islands and peninsulas, makes the interpretation of the channels and lochs of Pearl Harbor as a series of drowned dendritic valleys inadmissible. The erosion that has helped to shape the island forms there has not been to any great extent

subaërial. Erosion by the sea at present sea-level has played the major rôle in this process, but not even marine erosion has been the major factor in producing the lochs. The sea has worked in two ways, by tidal currents and by wave action. The currents have excavated the bottom of the channels; the waves are modifying the shape of the present shores. Wave erosion is much greater on those shores which are exposed to the northeast trade winds, since these winds are the agents which impart to the waves their greatest amplitude and power, and they are more constant than the winds from any other direction. Everywhere in the harbor, moreover, those shores which face the trade winds show a markedly greater degree of wave erosion than the shores that are in the lee of those winds. On the exposed shore of Waipio Peninsula along the middle channel a shelf produced by wave erosion was noted. Its upper surface was from a few inches to a foot or more below low water, and its width in this locality was estimated at 100 to 200 feet. At its edge the water suddenly increased in depth to an invisible bottom. This width was not at the point where the wave erosion had been greatest.

It is clear that wave erosion at present sea-level has reduced the size and modified the shores of the islands and peninsulas in Pearl Harbor from their original proportions, and that the process is still in progress. Wave erosion alone could not, however, have been the major factor in producing the lochs, since where they have worked with the greatest efficiency, at the northeast end of Ford Island, they have eroded only a few hundred feet of the shore since the last change of sea-level.

The surface of these islands and peninsulas is essentially that of the sea bottom of periods when the sea stood higher on the land than it does now. Subaërial erosion has modified these surfaces to a very minor degree since they have been exposed above the level of the sea. In altitude, slope and degree of subaërial erosion Ford Island and the seaward part of Waipio Peninsula correspond to the broad coral plain which extends from the mouth of Pearl Harbor westward to Barbers Point. The materials composing the coral plain and those that form

the visible parts of the island and peninsula were deposited beneath the sea under the same conditions of sea-level for both, except for the tuffs from the Salt Lake craters, which were deposited near their point of origin in greater amounts.

The three main lochs of Pearl Harbor are filling with silt around all their mainland shores, most rapidly in the vicinity of the streams that empty into them. They have never been any more nearly filled than they are now, except for the effect of wave erosion, and at the higher stands of the sea than the present one they were decidedly larger and deeper than now. These statements may not all apply to the smaller Southeast Loch, since local subsidence of volcanic tuff layers probably played a part in its origin.

PEARL HARBOR OF THE PERIOD BEFORE THE LAST SHIFT OF STRAND LINE

Wentworth and Palmer [14] have estimated the time elapsed since the last downward shift of strand line at about 5000 years, and Pollock [15] has supplied evidence based on the study of the growth-rate of coralline algae in the reefs of Oahu in very close agreement with their estimate. This short period, coupled with the scanty rainfall on the lee side of Oahu, particularly near the seacoast, accounts for the small part subaërial erosion has played in modifying the surface of the islands and peninsulas in Pearl Harbor.

Before the last shift of strand line, while Oahu was submerged about 20 feet more than now, the outlet channel of Pearl Harbor was about 2.5 miles wide. It extended westward over the coral plain more than a mile, and on the eastern side it covered the lower portion of the broad ridge of tuff which drifted on the wind from the Salt Lake Crater, but the sea-level of that time did not reach the present Puuloa entrance to the United States Navy reservation, since the altitude at that point is now about 30 feet. Though the main outlet channel of the earlier Pearl

[14] Wentworth, C. K. and Palmer, H. S., p. 530, as cited in note 9; also Wentworth, C. K., p. 120 of bulletin cited in note 3.

[15] Pollock, J. B., as cited in note 4.

Harbor was 2.5 miles wide, the larger area of water within the harbor required a larger volume of water displaced by tidal movements to flow in and out with each rise and fall of the tide; hence there were tidal currents of sufficient velocity to maintain open channels between the islands in the larger harbor, and prevent their filling up with either the growth of corals or other marine organisms, with wind-drifted volcanic ash, or with water-borne silt or mud. It seems feasible to ascertain the approximate depth of two of the earlier channels and to compare both with the sea-level of the earlier time and of the present.

If the conclusions are accepted which have already been reached in this study, that the present surface of the islands and peninsulas is that of the sea bottom of the earlier time, with very little modification by subaërial erosion, the slopes on the adjacent shores of Ford Island and Waipio Peninsula may be used to determine a minimum for the depth of the channel whose waters flowed between them at the higher sea-level. The approximate height of these shores was noted in their study. A line measured on the topographic map joining the 40-foot contours on that island and the adjacent part of the peninsula will give the distance between them when compared to the scale of the map, and the vertical drop from the 40-foot contours to the top of the shore cliffs will give the slope. These slopes, projected until they intersect, will mark approximately the middle of the older channel, and also the depth in relation to either the former or the present sea-level.

The required measurements and calculations showed that the sloping lines intersect each other between 13.5 and 14 feet below present sea-level, at a point one third of the width of the channel from Ford Island, and two thirds of its width from the Waipio shore. If the fundamental assumption is sound, namely, that the surface slope of the land here is approximately that of the old sea bottom, then the bottom of the channel of the former sea-level was about 14 feet below present sea-level, and 14 + 20, or 34 feet, below the sea-level of the former period. The depth of water in the present Middle Channel as indicated

on U. S. G. S. Map No. 4110 is $6\frac{1}{4}$ to $6\frac{3}{4}$ fathoms, or from 37.5 to 40.75 feet. This is a very satisfactory agreement of the results of the projection with the known data of the present harbor, and gives confidence in the method of arriving at the results. The fact that the projected lines intersect in the present channel only one third of the channel's width from Ford Island is accounted for by the much greater effectiveness of the wave erosion on the Waipio side, due to the influence of the trade winds on the height and power of the waves.

The same method was applied to East Channel, except that a projection from only one side was practicable. By using the slope from the 40-foot contour on Ford Island to the east corner of the island, and projecting it toward the southwest end of Kuahua Island, the depth at the middle of the channel was indicated as 16 feet below present sea-level, which, with the 20 feet of the change of sea-level, gives 36 feet as the probable depth of the channel of the former period. These results again are consistent with the others and with the present depth of this channel, which is about 40 feet below sea-level.

Another fact observed on the traverse of Ford Island, and not previously recorded, supports the conclusion that the channel of the former sea-level had its greatest depth below present sea-level and partly covered the present shore of Ford Island. On the shore of this island along that part of Middle Channel nearest to Middle Loch, the shore is lower and flatter than anywhere else around the island, and back from this shore some rods there is a sudden rise in the land to a ridge running parallel to the shore. The significance of this feature was not appreciated at the time of the observation, nor until all the facts upon which this study is based were analyzed and resynthesized. The topography in that locality was then recalled, but its description must be given only as remembered nearly four years afterwards, without exact quantitative data. An estimate based on such recollection makes the flat strip of land along the shore 5 to 10 rods wide, with a rise from water-line of about 5 to 8 feet, or perhaps even more, followed by a sudden rise of 10 to 15 feet to the top of the ridge, in a horizontal distance very much less

than the width of the flat strip. In short, the flat area is best interpreted as part of the channel bottom of the time when the land was submerged about 20 feet more than now, and the ridge as the remnant of the shore cliff of that same period.

The Middle Channel of the older time had its eastern shore farther eastward than that of the present one, and this is in harmony with the fact that the two lines projected from Ford Island and Waipio Peninsula intersect at a point only one third of the width of the present channel from Ford Island. The older channel bottom was partly on what is now Ford Island and partly below the water surface of the present channel. In other words, the channel bottom was only partly exposed at the time of the last emergence. In fact, the topography on this part of Ford Island fits into the interpretation of Pearl Harbor here presented like the last piece in a picture puzzle, the fitting of which proves the correctness of the whole arrangement. It may be concluded with a very high degree of certainty that the present channels in Pearl Harbor have not been eroded in horizontal strata by subaërial erosion, but that they have been eroded in the bottom of older marine channels, formed at a time when strand line stood 20 feet higher on the land than it does now. The erosion that produced the present channels has been that of tidal currents and waves at present sea-level. The waves are most effective on those shores that face the northeast trade winds, with the result that the present channels have been shifted somewhat to the westward, as compared with the older channels, and the older shore-lines have been more or less obliterated by the wave erosion on the eastern side of Ford Island and Waipio Peninsula. The central part of the bottom of the older channels was not raised above present sea-level by the last shift, but was about 14 to 16 feet below it. This is a fact that makes impossible the erosion of the channel between Kuahua Island and the nearest mainland shore, by either subaërial erosion or tidal currents, since the shores of that channel rise about 20 feet above present sea-level. The only other explanation that occurs to the writer is the one already given, that Kuahua Channel was formed by a local subsidence of the tuff deposits.

The visible features of Pearl Harbor have been developed at three different stands of sea-level, the present one and two earlier. The oldest and highest must have been a little more than 40 feet, since some marine deposits on Ford Island and Waipio Peninsula lie at that elevation. On the basis of other evidence Wentworth [16] has recognized these different levels and called the one at 40 feet the Waialae stage. He finds that at this stage the Salt Lake craters were active, and the sea-cliffs were cut on the Koolau spurs. During this time Pearl Harbor was a broad bay with an outlet about five miles wide, and having no island nor peninsula within its borders, except possibly three or four small shoals awash at low tide, the high points on Ford Island and Waipio Peninsula as they now exist. There is no clue to the time at which the shift occurred from the 40-foot to the 20-foot level, though Wentworth has estimated post-Waialae time as of the order of 100,000 to 200,000 years. The stage at which benches were cut on different islands of the Hawaiian group he called the Hanauma stage, since the benches are well shown at Hanauma Bay, Oahu. He believed this stage to have been only 12 feet above present sea-level, but evidence disclosed at Makalapa Crater proves it to have been about 20 feet. At this time there were three or four small shoals in Pearl Harbor, and after the formation of Kuahua Island and Makalapa Crater, which occurred at least before the end of this time, there were an additional island and a peninsula around the crater. This stage continued for some time after the eruptions at the Salt Lake and Makalapa craters came to an end, and calcareous deposits on Makalapa Crater showed the height of strand line during this stage. At the time of the last shift of sea-level Ford Island grew larger, two or three of the islands or shoals were transformed into Waipio Peninsula, and the Pearl City Peninsula came into existence, unless the low-lying necks of both the peninsulas have been formed by deposits of silt since the last shift. The last two major events in the development of Pearl Harbor were not submergences that drowned eroded valleys, but emergences that brought certain portions of the sea bottom above

[16] Wentworth, C. K., p. 119 of bulletin cited in note 3.

sea-level. The two shifts of strand line were about 20 feet each. The channels at the higher levels had a depth at least equal to that of the present channels, about 40 feet, and neither shift was sufficient to bring the bottom of the contemporaneous channels entirely above the sea-level established by the shift; hence there was no opportunity at either stage for fresh-water streams to do any work of erosion on the raised sea bottom, but tidal currents continued to flow in and out of the shallow channels and eroded them to a depth consonant with the volume and velocity of the water. At each stand of the sea, wave erosion added its effect to that of the tidal currents.

If Wentworth's conclusions are correct the sea stood at the 40-foot level for a period so long that it extended far back into the glacial epoch. He ascribes the Fort Shafter gravels to the Pleistocene, and they were deposited at the 40-foot stage of the sea. The shift to present strand line he ascribed to about 5000 years ago, and Pollock's calculations, based on the growth-rate of reef-forming coralline algae, are in close agreement with Wentworth's estimates.

SUMMARY

The story of Pearl Harbor may now be summarized in accordance with the facts herein reported and with the logical conclusions that may be drawn from these facts.

The site of Pearl Harbor was originally a broadly open, nearly semicircular bay between two volcanic mountain masses which at first were separate, but later fused into one. On the basis of present sea-level its radii were 3.5 to 4 miles, the width across the mouth about 8 miles, and its depth at the converging point of the radii, Waipio Point, not less than 1500 feet. Since its origin these 1500 feet have been completely filled with deposits laid beneath the sea, and such deposits are now found within the harbor to an altitude of 40 feet above existing sea-level. The deposits now above the sea represent the product of two different sea-levels higher on the land than the present one. At the higher level the island was submerged not less than 40 feet, perhaps slightly more. The other was more recent,

and the submergence immediately preceded and was about 20 feet greater than the present one. Wentworth has named the stage at 40 feet the Waialae stage, and the more recent one, which he believed to be at about 12 feet, but which was really about 20 feet, he has called the Hanauma stage.

The materials which filled the bay have been of three quite different kinds, chemically and physically: first, calcium carbonate, precipitated in sea water by marine plants and animals; second, volcanic tuff or ash thrown by explosive eruptions from the Salt Lake group of craters; and third, silt or mud brought down from the surrounding high land by the erosional action of fresh-water streams. The eastern third of the bay was filled chiefly, though not exclusively, by the tuff from the Salt Lake and Makalapa craters. Much of the tuff was thrown by the immediate force of the eruptions to its present resting place, and massive beds of this were probably continuous as far as Kuahua Island to an altitude of approximately 20 feet above present sea-level. Those massive beds were not continued across East Channel as far as Ford Island, at least not above present sea-level.

The finer ash from the Salt Lake craters drifted with the trade winds and formed a broad, gently sloping ridge which extends continuously as far as the main channel, where the upper layers of it are interstratified with calcareous materials, and at the top are covered by calcareous deposits in which corals are easily recognizable in considerable quantities. This same relation of calcareous and tufaceous materials may be seen at the seaward ends of both Ford Island and Waipio Peninsula, but they do not by any means compose the whole of those land masses.

The eruptions from the Salt Lake craters were in operation at the 40-foot stage and Makalapa Crater, the last of the craters in this vicinity, came to an end at the 20-foot stage. During the earlier and greater submergence, there were shoals, but no peninsulas nor islands and no definite channels in the harbor, and the entrance was five miles or more wide. At the 20-foot level there were several islands in the harbor with channels between them, through which tidal currents flowed about as now, but with a channel across Waipio Peninsula where none

now exists. While a remnant of the bottom of the former Middle Channel with a part of its shore cliff may be seen as a portion of the northwestern shore of Ford Island along the Middle Channel, the bottom at the center of the old channels was still about 14 to 16 feet below present sea-level. After the shift that brought the sea to its existing level (whether by a rising of the land or a sinking of the sea itself is not considered here), the present channels, except one, were eroded in the bottoms of former channels, and they have approximately the same depth now as the earlier ones below their respective sea-levels. The channel between Kuahua Island and the adjacent eastern shore was not formed by erosion, but it and other depressions both in the sea bottom and on the land in this vicinity, were probably formed mainly by local subsidence accompanying some of the volcanic eruptions in this region. None of the land forms in Pearl Harbor owe either their shape or their topography to subaërial erosion, except to a very minor degree. The materials composing them have been deposited in the sea, and the land forms have been shaped by the sea, that is, by tidal currents and wave erosion at present and former sea-levels.

The lochs of Pearl Harbor are not the product of subaërial erosion, forming dendritic valleys. They are much too broad and pouch-like at the head for that interpretation. For the most part they are areas that have never been filled to any greater degree than now, because the fresh water pouring into the bay prevented the growth of marine organisms that without this fresh water would have completely filled Pearl Harbor as it built up the coral plain to the westward. Wave erosion at present and former sea-level has modified the lochs to a small degree relatively, and stream erosion is filling them with silt. Five factors combined in filling Pearl Harbor and have worked together in such a way that at all stages in the filling process and at all the different levels of sea and land that have intervened since the semicircular bay was first outlined, the mouth of the harbor has filled up somewhat faster than the inner bays. The first factor is the marine currents along the shore, which deposit sand and other materials that they carry, behind projections, points of land

or similar obstacles, and across the mouths of open bays. The second is the waves of the open ocean which break on approaching the shore, and toss up sand banks across the mouths of open bays; the tidal currents sweeping into and out of the bays only in part counteracted those two tendencies to fill the harbor mouth, but finally it was filled to sea-level or slightly above, except for a relatively narrow and shallow channel. The third factor is the growth on the sea bottom of marine plants and animals that secrete calcium carbonate. These have played a large part in forming the visible deposits in Pearl Harbor, particularly since the bottom was filled to a level at which these organisms could grow throughout the area of the bay except along the inland shores, where the inflow of fresh water prevented it. The fourth factor, and this has been especially effective in the eastern part of Pearl Harbor, has been the volcanic eruptions from the Salt Lake craters. The massive deposits, thrown to their present location by the immediate force of the explosion, do not extend quite half-way across the original basin above present sea-level, but the finer ash was carried by the trade wind farther to the southwestward and exactly in the direction to fill up the mouth of the harbor. These wind-carried deposits fell into the sea, and they are now to be seen along certain parts of the channels, but tidal currents readily swept them away to a sufficient amount to keep shallow channels open, even though they built up deposits to sea-level in the quieter waters. The fifth and last factor is fresh water poured into the inner bays. It diluted the sea water to such an extent that marine organisms could not grow on the inner border of the bay and thus the lochs were never filled. The effectiveness of this factor may be inferred from the fact that in all the coral seas of the world such basins remain more or less open as "natural harbors" opposite the mouths of all streams of considerable size. The slope of the land around Pearl Harbor causes a number of the largest streams on the island to converge toward it, and their combined supply of fresh water has been sufficient, at all stages of its development, to keep open the unusually broad bays, the lochs of Pearl Harbor. The silt brought by the fresh-

water streams has not been sufficient to keep pace in filling the inner bays with the marine agencies tending to fill the mouth of the bay, and those parts within the mouth of the harbor where the sea water was not diluted sufficiently to prevent the growth of marine organisms.

Southeast Loch, as well as the channel between Kuahua Island and the adjacent shore, probably owes its origin to local subsidence in the tuff layers which form the shore of that loch.

The conclusion of the whole study is that the simple interpretation of Pearl Harbor as a series of drowned dendritic valleys, formed by subaërial erosion, is entirely inadmissible. Except for the deposits of volcanic tuff and some probable local subsidences in those deposits on the eastern shore, the land forms in the harbor are marine deposits, have been shaped almost wholly by marine agencies, and subaërial erosion has modified their topography to a very slight degree. The channels have been formed by tidal currents and wave erosion, and the three main lochs have never been filled to much greater extent than now.

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THE STATUS OF LAKE ERIE IN PRESENT AND RECENT LAND-TILTING

FRANK BURSLEY TAYLOR

IN A paper presented before this Academy two years ago, the studies of Dr. G. K. Gilbert and Mr. Sherman Moore on present tilting of the land in the region of the Great Lakes was reviewed with some care, and the bearing of certain well-determined geological facts upon their results was pointed out. Both authors made painstaking studies of the gage readings of the water levels made by the U. S. Lake Survey, Gilbert's covering the period 1875–1895, or twenty years; Moore's covering the period 1895–1925, or thirty years next following Gilbert's period. All of Gilbert's data were available to Moore, so that the whole period studied by Moore was fifty years. Their results may be briefly summarized as follows:

Gilbert found that the average rate of present uplift amounted to 0.41 feet per 100 miles per century. By the same method Moore found for his thirty-year period 0.43 feet per 100 miles per century. But in determining the rate, neither of these authors took account of the fact that the uplifting, tilting movement did not affect the whole region covered by the gage readings.

In the detailed study of the ancient shore-lines of the Great Lakes, as set forth by the writer in the second half of *Monograph 53, U. S. Geological Survey* (1915), isobases marking lines of equal elevation or contours on the tilted plane show that the tilted surface declines toward the south-southwest (about S. 22° W.) to a certain line at which the tilted attitude of the ancient beaches ceases to exist. Beyond that line to the south the ancient shore-lines are now horizontal, as nearly as can be determined. This line, therefore, is the isobase of zero. It is not so sharply defined as is shown on the map, Figure 15,

but in the field its place is easily limited to a belt three to five miles wide, and with more points of measurement might be located within a mile. For convenience, this line is called *the hinge-line*, and the relatively wide area extending toward the

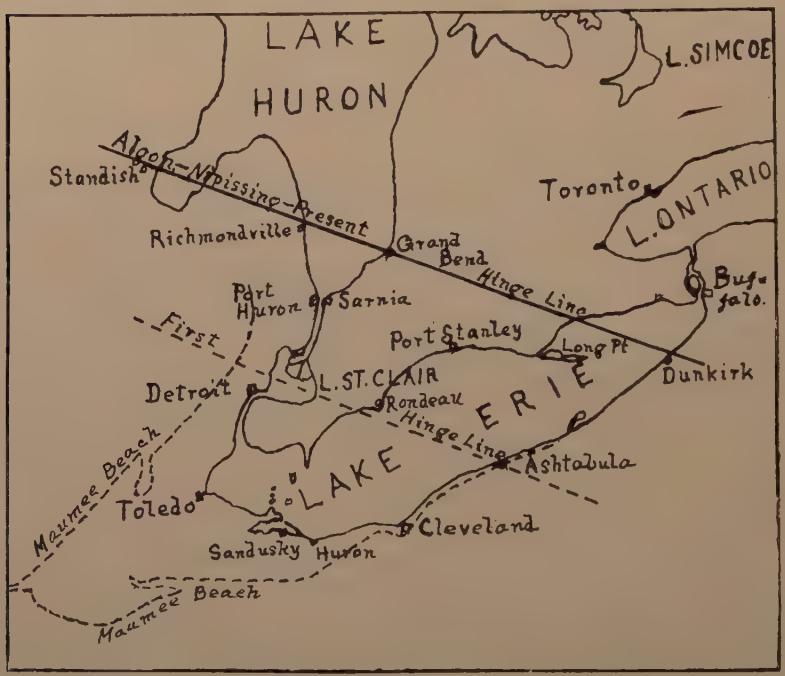

FIG. 15. Sketch map showing the place of the Algonquin-Nipissing-Present hinge-line and its production E. S. E. over Lake Erie. The Maumee beach is the oldest of the glacial lake beaches and is substantially horizontal from Fort Wayne, Indiana, to the First or Whittlesey hinge-line. The present area of horizontality extends up to the present hinge-line, beyond which toward the north-northeast tilting is now going on.

south, in which no measurable tilting is recorded, is called *the area of horizontality*. The older beaches had their hinge-lines a few miles farther south than the later ones (see *Monograph 53*, pp. 405 and 502–505). The Whittlesey hinge-line is the earliest one known. It is shown by a light broken line in Figure 15. The hinge-line of Glacial Lake Algonquin and also that

of the later non-glacial Nipissing Great Lakes occur together, no shifting of the line having taken place in the transition to the later stage, as shown in Figure 15. This line appears also to be the present hinge-line or zero isobase, for so far as careful observations have revealed, all the post-Nipissing beaches, including the Algoma beach and later fainter ones, appear to descend to this same line; and these are the latest or most recent of the abandoned shore-lines.

In determining the present rate of tilting, it is obvious that no true result can be obtained without taking account of the hinge-line and the area of horizontality. Recalculating the rates obtained by Gilbert and Moore, with proper allowances for this element of the problem, the writer found that the rate of tilting now going on north of the Algonquin-Nipissing hinge-line in Lakes Michigan and Huron is about 1.48 feet or, roughly, 1.5 feet per 100 miles per century. This epitome of the earlier paper seemed necessary in order to make clear what is now going on in the basin of Lake Erie.

For lack of space, the case for Lake Erie was not discussed in the paper presented two years ago. But the status of this lake in present and recent land-tilting is of considerable interest and importance. The present or Algonquin-Nipissing hinge-line crosses Saginaw Bay and the south part of Lake Huron, as shown in Figure 15, and is determined with considerable accuracy. If it be produced as a straight line running S. 78° E. across southern Ontario and Lake Erie, it will pass three or four miles north of Dunkirk, New York, and about 32 or 33 miles south-southwest of Buffalo, measured on the line of maximum rise which runs about N. 22° E. The outlet of Lake Erie being at Buffalo, which is within the area of recent and present land-tilting, makes the case of Lake Erie very different from that of Lakes Michigan and Huron in relation to present tilting. (The base used for drawing this hinge-line was the U. S. Lake Survey Chart of the Northern and Northwestern Lakes.)

In the absence of facts to the contrary, it is assumed for the purposes of the present paper that the Algonquin-Nipissing hinge-line is projected straight across southern Ontario and the north-

east end of Lake Erie, as shown in Figure 15. But it is to be remembered that this line does not and has not recently served as a hinge-line for the surface of the waters of Lake Erie, because Lake Erie's outlet is at Buffalo, and Buffalo is within the area of tilting and uplifting. Every inch that Buffalo is uplifted carries the water of Lake Erie up on its shores just that much, over the whole area southwest of the hinge-line, and in a diminishing amount northeast toward Buffalo. The hinge-line is, therefore, a submerged one, and is being submerged more and more deeply as the uplift at Buffalo goes on. The water is slowly rising on all the shores of the lake, except at the head of Niagara River at Buffalo. Over the submerged hinge-line, and at all points to the south and west, the water level in Lake Erie is rising at the same rate as the land is being uplifted at Buffalo. Taking Buffalo to be 32 or 33 miles north of the submerged hinge-line in the line of maximum rise, and by calculating the present rate of rise on the same basis as was employed in the calculation for Lakes Huron and Michigan, it is found that Buffalo, being only about one third of 100 miles north of the hinge-line, is being uplifted at about one third of the rate found for points 100 miles north of the hinge-line in Lake Huron or about 0.5 of a foot (six inches) per century. This is the theoretical solution of the problem. What facts are available for testing it?

The most important facts bearing on this question are those collected some years ago by Professor E. L. Moseley, formerly of the high school at Sandusky, Ohio, now head of the science department in the State Normal College of Northwestern Ohio, at Bowling Green.[1] Moseley found several different lines of evidence which, taken together, show conclusively that for more than a century and probably much longer the water of Lake Erie has been slowly rising and flooding the lands around the western part of the lake. Moseley found that all the streams which enter the western part show distinct evidences of drown-

[1] (1) "Lake Erie Enlarging," *The Lakeside Magazine*, Lakeside, Ohio, 1 (April, 1898): 14–17; (2) "Submerged Valleys in Sandusky Bay," *Nat. Geog. Mag.* 13 (1902): 398–403; (3) "Formations of Sandusky Bay and Cedar Point" (Ohio), President's Address in *Proc. Ohio Acad. of Sci.*, 14 (pt. 5, 1905): 179–238.

ing in recent time. The Huron River is a small stream, but it has deep, quiet water for five miles up from its mouth. Moseley traced the former bed of Sandusky River and several of its tributaries across the floor of Sandusky Bay, the general floor being a hard clay soil, while the old river beds are filled with soft fine mud of recent accumulation. Some of the drowned beds show a depth of 32 feet, while the former level of the lake at Sandusky could hardly have been less than 12 or 15 feet lower than now, with the beds eroded below that level. It is well known that the waves of a rising lake attack and erode the shore with much more power than do those of one whose level is not rising, and more than one whose level is falling. All around the western end of the lake, the loss of land to the lake by erosion of the shore has been relatively rapid in the last century and in recent decades. Certain islands near the mouth of Sandusky Bay have been entirely destroyed by wave action. Changes in the gravel and sand ridges of Cedar Point and of Sand Point opposite show the same order of change — a rising lake level. In many places stumps of large trees two to three hundred years old were found permanently under water. Some of them, such as black walnut and certain kinds of oak, do not grow in low, wet ground. In certain caves on Put-in-Bay Island there are stalagmites and stalactites now permanently submerged. The caves must have been above lake level when these forms were made. Moseley studied the flora of the islands, and found that the plant population shows clearly that the islands must have been a part of the mainland for a long time after the disappearance of the Wisconsin ice-sheet and its accompanying glacial lakes, before the recent rising of the waters flooded the low ground and separated the islands from the mainland. Moseley's papers contain much detailed and varied information which cannot be presented here.

My own investigations in the same region, carried on in connection with the study of the history of the Great Lakes, showed many facts of the same kind and bearing, especially with reference to the drowning of stream valleys and the erosion of the shore, but my work was not as thorough as that done by Moseley. I

found that the cutting away of the shore was very extensive on the north side of the lake also. Near Port Alma, midway between Point Pelee and Rondeau, the crest of a rather heavy water-laid moraine lay at least a mile or two to the south when the glacial lake waters withdrew, and subsequently small streams which drained toward the north made little valleys eight or ten feet wide and four or five feet deep. Since then the main part of the moraine has been cut away and the little valleys have been decapitated. It seems probable that at least three or four miles of the shore has been cut away in this place. Again, at Port Stanley, midway between Rondeau and Long Point, the recession of the shore has been very heavy. Long Point is a great spit built out from a projecting point of the north shore by shore-currents moving from the west. Its length of 20 miles and the fact that its outer part is projected into water 20 to 25 fathoms deep show the great work done by the waves on the shore to the west. The arrangement of the gravel and sand-bars of which the point is made is also very significant. They show clearly that early in its history the shore for many miles to the west was much farther out (toward the south) than it is now. It seems quite probable that at least ten to twelve miles of land has been cut away off Port Stanley. Presque Isle Point at Erie, Pennsylvania, is of the same origin, but the shore to the southwest was much less favorable for rapid and deep recession. The fact that the lake level was slowly rising for several thousands of years and that the area of the lake was constantly expanding greatly increased the efficiency of the waves in cutting away the shore.

From a study of the old ridges in the ridge section of Cedar Point, Moseley deduced a rate for the tilting of the land which caused the drowning, and found that the lake level has been rising at the rate of 2.14 feet per century (pages 223–236 of third paper referred to above). But the length of time covered by the data available to Moseley was relatively short, and several of the factors involved are incapable of exact valuation. It is believed that the rate obtained from the corrected results of Gilbert and Moore, as given above, is probably much nearer the truth, and it has the great advantage that it can be quite

closely checked by data from Niagara history and also from the history of the upper lakes.

The history of Lake Erie is very closely associated with the history of Niagara River and the Falls.[2] The newest section of the Niagara gorge, the section now being made by the present cataract, is called the Upper Great gorge. It begins about 500 feet above the upper railroad bridge, and extends about two and one-fifth miles up to the present Canadian or Horseshoe Fall. It is wide and deep, and was obviously made by the falls with 100 per cent volume, i.e., with the full discharge of the four lakes above the falls. The recession of the Canadian Fall is somewhat irregular in its rate, but a calculation made in 1913, based on all of the surveys from the first by James Hall in 1841, showed the rate to be approximately 4.5 feet per year. If this rate were exact the time taken to make this section would be about 2800 years. The time has generally been stated as 2700 to 3000 years, but there are certain features in the Upper Great gorge which strongly suggest some slowing of the rate and hence a slightly longer total time. Beginning at a point about one third of a mile north of the International Bridge, the heavy, massive, capping layer of the Lockport dolomite is about 40 feet thicker than it has been in the last mile of the gorge-making. This is believed to justify the extension of the estimated time from 2700 or 2800 years to 3000 years, and the latter number is, therefore, taken as probably nearest to the truth.

During the whole time of the making of this section, Lake Erie has been at high stage, receiving the full discharge of the three lakes above, and discharging this in addition to its own overflow through Niagara River, thus giving the cataract 100 per cent volume. Moseley's observations cover about the last tenth or eleventh of the time of this period. If for thirty centuries the rate of uplift at Buffalo has been 0.5 feet per century, the water level in the west end of the lake ought to have risen about 15 feet in the 3000 years since the Upper Great gorge began to be made and the full-volume cataract began work close above

[2] *The Niagara Folio, U. S. Geological Survey*, Folio No. 190, 1913, by E. M. Kindle and Frank B. Taylor. See large-scale map of gorge.

the railroad bridges. The old lake-level or base-level, to which Moseley found the tributary streams had been cutting when the lake was at low stage, was about 12 to 15 feet below present lake-level. Thus, his result agrees very closely with that obtained from the corrected results of Gilbert and Moore checked by the time factor obtained from the making of the Upper Great gorge of Niagara. Moseley's rate of tilting as affecting Lake Erie is more than four times greater than that obtained by the other method, but it is to be remembered that his papers were published long before any attempt had been made to extend the corrected rate of uplift to Buffalo or Lake Erie.

When the retreating Wisconsin ice-sheet withdrew from the Mattawa and Ottawa valleys between North Bay and Pembroke, Ontario, the whole discharge of the three upper lakes passed eastward through these valleys to the sea near the latter place, leaving Niagara with only the overflow from Lake Erie, which is equal to about 15 per cent of the full four-lake volume. For 2000 or 3000 years before this time, Niagara had had full four-lake volume, while the Lower Great gorge was being made, but now 85 per cent of its volume was suddenly taken away. In the gorge, this event is marked by the sudden and strongly marked narrowing and shallowing at the south side of the Eddy basin which lies next north of the gorge of the Whirlpool rapids. But the tilting of the land was constantly going on, and the place of the outlet at North Bay was finally raised to a higher level than the outlet at Port Huron, and the discharge of the Upper lakes then came back to Lake Erie and Niagara. The place marking this event is close above the railroad bridges, where the gorge suddenly becomes wide and deep. The gorge of the Whirlpool rapids is about three fourths of a mile long and is narrow and shallow as compared with the full-volume gorge sections next above and below. This section is the precise correlative of the period during which the North Bay outlet was active, and since, from the rate of erosion of the Upper Great gorge, we found that it was about 3000 years since the full-volume cataract began work just above the railroad bridges, it is also about 3000 years since the outlet at North Bay was closed. On

the line of maximum rise on the tilted plane, about N. 22° E., the distance from Port Huron to North Bay is about 238 miles. At this distance north of the isobase of zero, the rate of uplift at 1.48 feet per 100 miles per century would be 3.52 feet per century, and in 3000 years the total amount of uplift would be 105.60 feet. As determined by instrumental surveys made by J. W. Goldthwait and the writer in 1908, the Nipissing beach at Sarnia has an altitude of 597 feet above sea-level, or 16 feet above Lake Huron at that time. At North Bay the same beach was 698 feet above sea-level, or 117 feet above Lake Huron.[3] This makes the Nipissing beach at North Bay 101 feet above the same beach at Sarnia, and the outlet at North Bay has, therefore, been uplifted by the tilting of the land by that amount in the last 3000 years, approximately, or since that outlet was abandoned. This result of 101 feet by instrumental survey compares rather closely with 105.60 feet, as determined from the corrected calculations of Gilbert and Moore from gage readings covering a period of 50 years (1875–1925). From results so accordant as these, showing only 4.60 feet difference, one may project the line by extrapolation to Buffalo and Lake Erie with some degree of confidence that it will not be far from the truth. But of course the small difference of 4.60 feet cannot be depended upon as wholly accurate; it is probably in some measure accidental, but may be taken as showing that the accordance is close.

In approximately 3000 years, then, the waters of Lake Erie south and west of the submerged hinge-line have risen something like 15 feet. To ignore the recent very low stage, which is probably temporary, the difference between the levels of Lake Michigan-Huron and Lake Erie was about eight feet. If the tilting, with uplift at Buffalo, goes on at the same rate in the future, these lakes will come to one level in about 1600 years. If we suppose the original rock still at the head of the outlet at Chicago to have been eight feet above Lake Michigan, it would take about another 1600 years for the water to begin to flow over at Chicago, and perhaps still another 1600 years before the whole discharge would pass that way. This, as now interpreted, would be the course of

[3] *U. S. Geological Survey, Monograph No. 53*, 1915, p. 459.

nature undisturbed if the rate of tilting is uniform. But with man interfering both at Chicago and Buffalo, the direction and amount of discharge will probably be controlled, and safe predictions can hardly be made. Cities, towns and harbors on Lake Erie and Detroit River will be seriously affected by the rise of Lake Erie, and those on Lake St. Clair and St. Clair River in less degree.

Tilting of the land in the region of the Great Lakes had been going on for a long time before the beginning of the period here discussed (reaching back about 3000 years). Gilbert and Spencer picture Lake Erie at its first stage as an independent lake following the retreat of the Wisconsin ice-sheet, and as extending from Buffalo only about as far west as Erie, Pennsylvania — but that is a rather long and complicated story, and will not be entered into here.

Fort Wayne, Indiana

AUGUST STRINDBERG
THE FATHER OF DRAMATIC EXPRESSIONISM

CARL DAHLSTROM

IT WOULD seem that any person who has read Strindberg's play *The Father* would be far too wary to select a subject that involves fatherhood. Yet the evidence is such that there is no escape for the dramatist. German critics have been almost in complete accord regarding Strindberg's position as the father of modern expressionism.[1] In fact, that part of the question has been settled to such a degree that it is no longer material for much debate. Of far more interest and consequence is the question regarding the nature of Strindberg's dramatic expressionism. Or, if you will, what kind of father was he to this modern movement?

It would be extremely convenient for us if expressionism were all nicely boxed, with no question concerning the nature of the movement; for then everyone would be acquainted with the concepts and we could begin immediately with Strindberg's work. It is, however, not boxed; and we, consequently, shall have to gather up the items in a little preliminary discussion.

A synthetic study of a large number of critics and exponents of expressionism[2] will at first give the impression that confusion alone reigns, that it is impossible to get any order out of the chaos of material. Yet if one persists in the study, and also maintains at least a small degree of sanity, one is surprised to note that control factors actually come floating out of this word-

[1] These critics recognize, of course, that expressionism has a large number of ancestors; but Strindberg is usually given the position of *father* owing to his conscious development of a new form of drama and his immediate influence on the modern German school.

[2] See the short list in the bibliography; consult, especially, Soergel's encyclopedic work.

welter. In spite of contradictions among critics there is enough agreement to establish what we may term the inner limits of expressionism.

(1) In the first place it is unanimously agreed that this art is subjective; and, more than that — that it is super-subjective! Expressionism turns its back on the object and fastens almost exclusive attention on the subject. It admits that there is such a relation as subject-object in our universe, but it cries out for complete emphasis on the subject. Whatever essential reality can be grasped will not be found in the material stuff of our universe, but in the soul-stuff, in the ego. The Absolute is in constant play in the magic crystal of the ego. Whosoever has eyes, then, let him turn them to this magic crystal within himself and he shall see essential reality. Whosoever has talent, let him reproduce what he sees within his "self." Indeed, only that which has flowed through the ego is fit content for art, because it is closest to the heart of reality. Consequently, in expressionistic art one of the main factors is this flowing from the ego, this radiation from the self, this *Ausstrahlungen des Ichs*.

In dramatic literature the application of this principle leads to the employment of autobiographical data — not exclusively, but frequently. Furthermore, inasmuch as this material is a reflection of the Absolute, it will not remain individual but will be generalized. In drama, for instance, the characters will not be individuals, but types. Again, nearly all the characters in a drama, if not all, will be materializations of the writer's ego, or of his spokesman's ego; and we shall find that drama at times is monologue, even though a dialogue is maintained between the principal character and his "selves" or the creatures of his own ego.

In addition, this subject-object relationship which is reflected in the ego in absolute form can only be symbolized in the struggle of opposites, especially of elemental opposites. For example, the struggle will be maintained between male and female, father and son, burghers and intellectuals, wealthy and poor, or between any other antithetical forces of equal validity.

From *Ausstrahlungen des Ichs*, then, we gather factors like

autobiographical material, typification, struggle of opposites, and a specific kind of monologue.

(2) The second factor is in the embrace of the first. This is obvious, since the *Absolute* is in play in the ego! The *Unconscious* also plays a high part in this solipsistic art. Whosoever directs his gaze into the ego must depend on intuition for knowledge, and must gather automatically into consciousness the stuff that surges in the regions of the Unconscious. In drama we get a dream fabric, for dream life seems the closest approach to experiences in the Unconscious. As a direct consequence of the dream form we also obtain distortion of the art form and of observed reality. The dramatic unities are no longer necessary; they may be maintained or they may be ignored. Likewise, the material projected on the stage may be in accord with observed reality, or may be a dream version with elements distorted or their arrangement in observed reality totally broken; or both the elements and their arrangement may be distorted. It is a psychic complex that is on the stage and this cares nothing for the ordinary rules either of drama or of the empirical world. The factor of the *Unconscious*, therefore, is responsible for dream fabric and distortion; for the art form gathers into itself the *inner* experiences of the artist.

(3) *Soul* is the third factor. When one turns his back on objective reality one is sooner or later unconcerned regarding the conventions of the empirical world. The Absolute is in play in the ego, and *soul* becomes its own law. With emphasis on *soul* we acquire a surge of feeling that reaches ecstasy or else the wild cry of the primitive. If we have ecstasy we may gain lyrical qualities for our literature; if we have the primitive element we may develop the wild yell of the savage. Expressionism, however, would have something between divine ecstasy and brutal primitivity, would capture that *ur*-form of soul that was in primitive man and still exists in the modern creature. This enduring quality of soul cannot be described merely as primitivity or as ecstatic feeling, so we coin a word on the German prefix *ur* — *urishness*. It is this urishness that qualifies the element of *soul*.

(4) Expressionism is also related to music. The latter is the purest of subjective arts, for it can transmute objective experience into an art form that no longer harks back to the original source of experience. Music gives immediately the inner experiences. The other arts would do the same, would give in an unpronounced form this inner experience without so closely referring to the stimulating object. The search for this form has brought to painting the contrapuntal method, progressive variations of lines and forms. In drama, however, the search has occasioned the employment of music to add to the mood of a situation; or to create the proper mood by immediately preceding an act. The music is not considered as something extraneous, but as a functional part of the drama. It is to build up the spirit of the drama without attracting attention to itself.

This material is given rather tersely, and admittedly does not round out the concepts in expressionism; but, under the circumstances, it must suffice. It is at least sufficient and inclusive enough to give us factors for the examination of dramatic literature. If we focus our attention especially on *Ausstrahlungen des Ichs*, the radiation of the Absolute from the magic crystal of the ego, we shall have the most vital and outstanding factor in expressionism, for it conditions all other elements.

STRINDBERG'S *TO DAMASCUS* (1897–1904)

We are now in a better position to determine the nature of Strindberg's expressionism. It is obvious, I trust, that of the sixty and more dramas written by Strindberg we shall have to be content with one single item. Of all the dramas the first part of the *To Damascus* trilogy is the most significant, both for the excellence of its form and the variety of material in the play. The analysis could begin with the list of the dramatis personae and continue page by page to the end gathering a rich harvest throughout. We shall make this analysis — *skippingly*, however!

Note in the first place the list of characters for this drama. None is qualified by individuality, but, on the other hand, by profession, sex, social or family status: to wit, the Unknown,

the Lady, the Beggar, the Sister, the Old Man, the Mother, the Abbess, the Confessor, subordinate characters and shadows. Here are types, unless the dramatist has given individual qualification and character delineation in the play. A short excursion through the drama will give us opportunity to determine the nature of the characters and of the work itself.

The drama opens on a street corner with the Unknown undecided regarding the direction he will take. A Lady enters, greets the Unknown, intends to pass but stays.

The Unknown: See, there you are. I almost knew that you would come.

The Lady: You were calling for me then. Yes, I felt it.[3]

At the very opening of the drama we have this very close association between two characters; so close, in fact, that at least telepathy is in play between them. The Lady certainly comes to the Unknown as a fulfilment of his wish. We obtain more insight into the nature of this Lady when the Unknown requests her to talk a little about herself. She replies that there is nothing to discuss; there is apparently only a *tabula rasa* in the form of a woman. The Unknown hastens to make up the deficiencies.

The Unknown: Peculiarly enough, I also would rather think of you as impersonal, nameless — I only know the half of your name — I should like to give you a name myself — let me think what you shall be called! Yes, you shall be named Eve.[4]

The name *Eve* has two obvious interpretations: The Lady is the type woman, the representative of the eternal feminine; and she is also the creature through whom sin came into the world.[5] She is like the flower that she wears on her bosom: it signifies meanness and slander, but has been known to heal insanity.[6] It seems rather clear that the Lady springs from the ego of the Unknown. She is nothing until he qualifies her with the name *Eve*, an age of thirty-four years, and a good character.

The Beggar is another peculiar character. We soon learn, however, that he is just a material manifestation of the Unknown.

[3] Strindberg, *Samlade Skrifter*, Vol. XXIX, p. 7. Future references containing only volume and page numbers are to this work. References to Volume XXIX will in general be given by page numbers alone.

[4] P. 13. [5] P. 87 ff. [6] P. 20.

In his conversation with the Lady, the Unknown called attention to a scar on his forehead and explained that he received it as a child when his brother struck him with an axe.[7] Later, in his conversation with the Beggar, the Unknown asks him what sort of scar he has on the forehead. He is frightened when he learns that the Beggar received it at the hands of a close relative.[8] Still later in the first scene the Beggar and the Unknown are practically identified as the same person by the tavern keeper. Both answer, in minute detail, the description of an individual wanted by the police.[9] The Beggar is clearly a material form of one of the Unknown's *selves*.

The scene "By the Seaside" is filled with expressionistic material. The Lady has been steadily engaged with crochet work, and the Unknown soon fastens his attention on the bit of fancy work.

The Unknown: What is it that you are working on so constantly; like one of the Parcae you sit there and draw the thread through your fingers . . . but do so! One of the most beautiful sights I can think of is to see a woman bent over her work or her child. What are you working on?

The Lady: It is nothing, just a bit of fancy work. . . .

The Unknown: It looks like a mesh of nerves and knots where your thoughts are fixed. I can imagine that your brain looks like that on the inside. . . .

The Lady: If only I had half the thoughts which you wish to ascribe to me; but I haven't any at all!

The Unknown: Probably that is why I enjoy your company so much, because I find you so complete that I can't think of an existence without you! — Now the cloud drew away! Now the heavens are high; the wind is soft — feel how it caresses! This is life! Yes, I live now, just now. And I feel my ego swell, expand, become thin, become infinite. I am everywhere, in the sea which is my blood, in the mountains which are my skeleton, in the trees, in the flowers. And my head reaches up into the heavens. I look out over the Universe which is my Self, and I feel the Creator's whole power in me, for I am that One. I should like to take the whole mass in my hand and knead it over again to something more complete, more enduring and more beautiful. . . . I should like to see every created thing and every creature happy: born without pain, live without sorrow, and die in quiet joy! Eve! will you die with me, now, in this very moment, since in the next one pain will sweep over us again? [10]

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[7] P. 13. [8] P. 18. [9] P. 26 ff. [10] P. 54.

The Unknown, the mouthpiece of the dramatist,[11] is clearly an expressionist. He is the super-subjective individual through whom world and ego unite in flux. We call to mind Pfister's words in his book on expressionism: "The expressionist creates out of the depths of things, because he knows himself to be in these depths, to paint out of himself and to paint himself means to reproduce the intrinsic nature of things, the Absolute. The artist creates as God creates, out of his own inner self, and in his own likeness."[12] The Unknown is this Absolute, this artist who creates as God creates. Note, also, how well he fits in with the expressionists who ". . . desire to reshape reality until the art-form emerges from the nature-form."[13] It is the Unknown who is reshaping the nature-form in *To Damascus*, and the drama is his ego enstaged.

The play is replete with evidence of the same order, but we turn to other factors. Throughout the drama the Unknown is in battle with the "Powers," with the Unseen One. Whether the "Powers" are good or evil is difficult to determine, but the struggle at least is very plain. It is also not readily grasped whether these powers are considered as having an existence apart from the Unknown's self, or if they are actually radiations from the main character. The "Powers" certainly are symbolized in the various characters who oppose the Unknown, for the evidence of the struggle lies almost wholly in the combat between the sexes, and between the individual and society. There is also an element of play, of the grotesque, in the Unknown's attitude toward the "Powers," as though he realized after all that he has even created the Unseen One in his own image. Not long after he has informed us that he is the Universe, the Creator, and the Absolute, the Unknown encounters financial difficulties.

[11] For the autobiographical nature of *To Damascus*, and the identification of Strindberg with the Unknown, see

(*a*) Lamm, *Strindbergs dramer*, Vol. II, p. 52 ff.
(*b*) Marcus, *Strindbergs Dramatik*, p. 231 ff.
(*c*) Diebold, *Anarchie im Drama*, p. 162 ff.
(*d*) Erdmann, *August Strindberg*, p. 709 ff.
(*e*) Soergel, *Dichtung u. Dichter d. Zeit*, p. 190 ff.

[12] Pfister, *Expressionism in Art*, p. 189 ff.

[13] Marzynski, *Expressionismus*, p. 55.

So he cries out against the "Powers" in the manner of a man who curses to relieve himself of too much tension.

The Unknown: . . . Now the glove is cast, and you shall witness a set-to between big folk! (He opens his coat and vest and casts threatening glances upwards.) Come! Strike me with your thunder, if you dare! Scare me with your storm, if you can!

The Lady: No, no! Don't do that!

The Unknown: Yes, just that! that! Who ventures to disturb me in my love dream? Who snatches the cup from my lips and the woman from my arms? Ye envious ones, gods or devils! Little burgher-gods who parry the sword with a thrust of the needle from behind; who don't meet in the field, but answer with an unpaid bill at the kitchen in order to belittle the master before his servants. Not to strike, to hew with naked metal, but to spit upon and to yell . . . fie! Powers, potentates, princes, fie!

The Lady: May heaven never punish you. . . .

The Unknown: The heavens are just as blue and just as mute . . . the sea is just as blue and stupid. . . .[14]

This passage indicates that the "Powers" are quite likely to be projections from the mind of the Unknown. Certainly the Unknown is contemptuous of the Unseen One in the passage just quoted, and a little more so when he cries out, "I should like to spit Fate in the face."[15] Toward the end of the first part of the trilogy, however, the Unseen One takes on more character. The Unknown admits that he wronged the "Powers" by misjudging them; but in the next breath says that all his troubles were due to his own stupidity.[16] The "Powers," like other characters in the drama, seem like material manifestations from the troubled conscience of the Unknown; they are real only in the Unknown's ego.

The Unknown's concept of reality is quite in accord with expressionistic notions and points also to the dream fabric of the drama. In the first scene the Lady reproaches the Unknown because he is playing with death. The reply of the latter gives a cue to his idea of reality.

[14] Strindberg, *Samlade Skrifter*, Vol. XXIX, p. 58.
[15] P. 83. [16] P. 135.

> The Unknown: Just as I play with life — I was a writer. In spite of my inborn gloominess I have never been able to take things seriously, not even my own great sorrows, and there are moments when I doubt that life has any more reality than my own writings.[17]

The expressionists take things far more seriously than the Unknown, but they certainly would declare that there is more reality in works of art, expressionistic art, than in observed reality itself. For observed reality is only a superficial manifestation of essential reality; the latter is born within the ego which collects all the items from the empirical world and transmutes them into the Absolute. The Unknown also recognizes this condition when he says,

> . . . It seems as though I am lying all hacked to pieces in Medea's kettle and cooking slowly: either I shall be going to the soap-works or else shall arise rejuvenated from my own bouillon! All depends on Medea's proficiency.[18]

The figure of speech may well apply to conditions of reality: All the elements of observed reality are hacked to fine pieces when poured into the unconscious; dependent on the proficiency of the ego a new inner experience is born or else everything becomes mere refuse. It is only from *his own bouillon* that the Unknown can arise rejuvenated!

There is one more factor that must be touched upon before the picture of *To Damascus, I*, is fairly complete: the relation to music. In the first scene a funeral march approaches and draws away, to the discomfort of the Unknown. When he has named the Lady *Eve* and exuberantly cries out for fanfares, the funeral march answers.[19] Later, the playing of the organ in the church serves as an announcement that the tavern will soon be open and one may begin to drink again. Likewise, when the Unknown is uncomfortably involved in the tavern scene, taunted with being wanted by the police, he cries out that it looks much like an intrigue. The vision is at once broken by music. The church bells ring; and one hears the organ playing and the choir singing as the sun comes out in brilliance.[20] In the scene "At the Doctor's House" the Unknown hears once more

[17] P. 9. [18] P. 23. [19] P. 13. [20] P. 28.

Mendelssohn's *Funeral March*, and it is clear that the music is tormenting him, if not actually pursuing him.[21] Throughout the play, in fact, music contributes to the moods of the various situations.

A study of the scene arrangement reveals a new form. Strindberg has commented on this form in letters, and especially in a little foreword to his play *The Regent* in which he refers to this arrangement as a contrapuntal form.[22] The drama begins at the street corner, passes to the Doctor's house, the hotel room, the seaside, the highway, the gorge, the kitchen, the rose-room, and the asylum. The play mounts up and up until the asylum scene comes as a climax; then it tumbles away through the same scenes in reverse order until once more we have the Unknown seated on the street corner, writing in the sand.

This so-called contrapuntal form is given not simply in the scene arrangement, but also in the dialogue. It is the musical theme dialogue which Strindberg promised in *Miss Julia* but practically failed to develop.[23] *To Damascus, I*, fulfils the promise. Very early in the play, the Unknown informs the Lady that he has no more sins on his conscience than other people walking about unmolested by the police — except one: "I didn't wish to be life's fool."[24] The same idea is expressed once more with a little variation: "I did not want to be life's dupe";[25] and then again with the addition "and therefore I became it!"[26] If we look further in the other parts of *To Damascus, I*, we find the same idea coming again in Father Melcher's discussion of Kierkegaard: ". . . because he did not wish to be life's fool he wrote articles under different pseudonyms, representing each as a 'Station on the Road of Life' . . . but the Lord of life made him the fool in spite of all his precautions."[27]

The significance of the Lady's fancy work is also conjured up either through stage directions — "the Lady crochets" — or else by reference in the dialogue itself.[28] Similarly, the Unknown's writing in the sand has the effect of the reiteration of a musical theme as well as an allusion to biblical material.[29]

[21] P. 38. [22] Vol. XLIX, p. 138. [23] Vol. XXIII, p. 108.
[24] Vol. XXIX, p. 10. [25] P. 102. [26] P. 135. [27] P. 357.
[28] Pp. 12, 37, 45, 51, 52, 54, 59, 79, 93, 121, 125.
[29] Pp. 16, 19, 20, 24, 133 (see Bible, John 8:6).

Ideas that play in and out of the dialogue are — money and financial distress,[30] conscience,[31] hate,[32] insanity,[33] suffering,[34] the "deliverer,"[35] and the Unknown pictured as Mephistopheles, or as one who is already damned.[36] These come into our consciousness again and again like harmonies or dissonances sounded before. The ideas do not always appear in exactly the same form, but they do nevertheless contribute to the fundamental thought of each theme. Here is the contrapuntal form of dialogue which tries to accomplish in dramatics what optical counterpoint attempted in expressionistic painting.

The asylum scene is probably the most remarkable of all in this relation of drama to music. It contains practically everything that has appeared earlier in the drama by the inclusion of shadow characters representing the dramatis personae and even those who were only mentioned in the dialogue. The brown-clad funeral assistants are there to recall the dream scene at the tavern early in the drama; a woman in mourning with her two children represents the Unknown's first wife and children; the shadow forms of the Lady, of the Doctor, of "Caesar," and of others are all gathered in this one scene. Likewise the conversation between the Unknown and the Abbess calls back to mind scenes and dialogues that have been given earlier. The asylum becomes a phantasmagoria of the first part of the drama and is an excellent example of the so-called contrapuntal method.

This material is decidedly meager and does not pretend to give a complete analysis of the first part of *To Damascus*. Yet it should give some indication of the nature of Strindberg's dramatic expressionism. The drama is pure *Ausstrahlungen des Ichs*, with the main character, the Unknown, an expressionistic monologist. The philosophy of the Unknown is quite in harmony with expressionistic theory in its super-subjectivism. Like-

[30] Pp. 18, 22, 45, 49, 53, 57, 62, 65, 67, 73, 74, 77, 83, 90, 101, 103, 113, 134.
[31] Pp. 10, 23, 65, 72, 85, 96, 107, 113, 119, 132.
[32] Pp. 11, 13, 14, 33, 42, 82, 83, 99, 102, 103, 131.
[33] Pp. 15, 20, 28, 33, 40, 50, 89, 98, 123, 129, 130.
[34] Pp. 23, 55, 69, 108, 119, 121, 122, 124, 131.
[35] Pp. 15, 21, 27, 30, 31, 37, 45, 52, 64, 93, 119, 124.
[36] Pp. 8, 30, 34, 57, 66, 76, 89, 103, 116–117.

wise, there is the elemental struggle of the Unknown against the "Powers," the Unseen One; characters are typical; observed reality is distorted in the process of projecting inner experience into the drama; and, finally, the so-called contrapuntal method is employed both in staging and in dialogue.

Strindberg reproduced what he saw of the Absolute in the magic crystal of the ego. Whether it is adequate or not is a question outside our immediate province. *To Damascus, I*, is expressionistic in every sense, and it well illustrates the nature of Strindberg's fatherhood of expressionism.

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ADDITIONS TO A VOLUME ON THE SLANG AND THE IDIOMS OF THE WORLD WAR

EUGENE S. McCARTNEY

DURING the course of the World War belligerent governments found time to make some provision for the military museums they planned to establish after the conflict. Large collections of photographs illustrating the machines and the methods of warfare were likewise made. Less important, but still worthy of serious consideration, is the language of the trenches. Before the war was over books and pamphlets had been written on the military slang of the French and German armies, and, strange to say, even upon that of the Swiss army.

In both American and English newspapers and magazines some attention was paid to the linguistic phenomena of the war, but the first effort to organize and systematize in dictionary form the rich and varied vocabulary of either of the English-speaking nations is a 372-page volume by Edward Fraser and John Gibbons, *Soldier and Sailor Words and Phrases*,[1] which was compiled "at the instance of the authorities of the Imperial War Museum." This is devoted primarily to the terms used by the British soldier, but "A number of American service words and expressions, particularly some that became familiar among British troops during the war, have been included" (Prefatory Note, p. v).

While the war was still raging I collected all the military slang and expressions that I could find in French, German and English. The present compilation represents material from many English and American sources, but I have excluded all words found in the volume mentioned above unless I have an additional item about them. I have some eleven hundred words and expressions.

A number of war-time expressions have been incorporated into

[1] E. P. Dutton & Co., New York; George Routledge & Sons, London, 1925.

our language, but not nearly so many as people expected. Popular books written by participants in the war before its conclusion contain many words that are now unintelligible to the younger generation which has come to maturity since the war.

No claim is made that all the words in this list are slang. Any usage or any expression which had some special war-time association has been considered eligible for inclusion. Occasionally a technical word or a foreign phrase has been incorporated. It should not be inferred, however, from the presence of a word in these pages that either it or its special meaning originated during the war. Many strange-looking words are much older, but it was the war that attracted attention to them. I have tried to check my original source of information by a second one, but a few words proved too elusive for me to adhere without exception to this policy.

My sources are not always consistent with one another, nor are they always free from obvious errors. In dealing with unscholarly material of this nature I cannot hope that my own list is entirely devoid of mistakes.

There are many pitfalls in making a study of this character, particularly if one tries to explain origins. Many absurd guesses have been given as facts. I have included a few of them for what they are worth. A most amusing example gives to "gone west" its figurative meaning "presumably because the Boche fires at our troops from east to west."

Had other volumes like that by Fraser and Gibbons appeared, I should have refrained from publication. Since the probability that similar works will be published is growing more remote,[2] it seemed worth while for me to render available the supplementary material in my collection.

The sources for most of my items will be found in the bibliography. It seemed hardly worth while to refer to scattered ephemeral publications for my other material. Some of my items I got orally from soldiers. I have made it a point, however, to give authorities for any data of unusual significance.

[2] In their Prefatory Note Fraser and Gibbons do speak of "a possible future edition" of their work.

It would be valuable information if one could always tell in which of the English-speaking armies these words and usages originated, but to only a comparatively few of them have I felt justified in ascribing a source. I do not mean to imply, however, that none of those words to which a source has been assigned passed over to the soldiers and sailors of the other nation. I have not always indicated a source for those words whose definition makes it obvious.

In an effort to attain approximate consistency I have made some minor changes in the style of quotations, particularly in reversing the position of punctuation marks and marks of quotation, and occasionally in putting certain words in italics instead of enclosing them in quotation marks.

The following abbreviations have been used:

Am. = American Army
Am. N. = American Navy
Br. = British Army
Br. N. = British Navy
Lit. Dig. = *The Literary Digest.*

An asterisk indicates that the word or expression is found also in the volume by Fraser and Gibbons.

When authors' names are given alone, the titles of their books will be found in the bibliography at the end of this list.

A

A. M. T. landing (Am.), an expression used at Kelly Field, Texas, to designate an airplane landing of such a character that the airman needed the services of an Ambulance, Motor-cycle or Truck to convey him to a hospital.

A. T. A. wallah, a teetotaller. The abbreviation stands for Army Temperance Association. *See* Wallah.

Abdul Pasha, a Turk. "A Turk was never a Turk. He was a Turkey, Abdul Pasha, or a cigarette maker." — J. Gallishaw, *Trenching at Gallipoli*, p. 135.

Ace of Diamonds Division (Am.), the Fifth Division, Regulars; called also "Red Diamond Division". Insignia, a red ace of diamonds.

***ack emma,** I, morning; II, an air mechanic. In the signaler's code it means A. M. *See* Signaler's Code, p. 322.

Acorn Division (Am.), the Eighty-seventh Division, composed of men from Arkansas, Mississippi and Louisiana. Insignia, a brown acorn on a green disc.

airnat (Am.), an airman. The word is said to have been formed from aëronaut and to have been adopted by balloting of the flying corps of the United States Army.

See *Aerial Age Weekly*, Nov. 4, 1918, p. 417. The word was utterly lacking in spontaneity and does not seem to have obtained any vogue.

Alamo Division (Am.), the Ninetieth Division, composed of Texas and Oklahoma troops. The name is very appropriate, since the division trained at Camp Travis, just outside San Antonio. Insignia, a red monogram "TO".

All American Division (Am.), the Eighty-second Division, composed largely of troops from Georgia, Alabama and Tennessee. It was said to owe its name to the fact that nearly every state in the Union was represented in its membership. Insignia, the letters "AA" in gold on a blue field, which in turn is set upon a red square.

allo, a radio notice that a U-boat had been seen.

almond rocks, *see* Sieda.

American ponies, Missouri mules, named with a covert allusion to Shetland ponies.

ammunition (Am.), pies and pastry, as doled out by the Salvation Army.

***angel** (Br.N.), the wireless operator or telegraphist, who was so called on account of the wings and forked lightning of his distinguishing badges. Other nicknames were "atmospherics", "sparks" and "juicey".

***Anzac** (Br.), a word formed by combining the initial letters of Australian-New Zealand Army Corps. One account says that publicity was given to the word by Major Oliver Hogue of Sydney, who used it as a code word in dispatches to *The Sydney Morning Herald.*

apartments, a dugout.

aprons, wires suspended from balloons at such intervals as to prevent big airplanes from getting through; nets formed by "kite-balloons, each a certain distance from the next, each connected to the next by a horizontal wire-cable, and each horizontal cable carrying suspended from it at intervals some thousands of feet of fine wire, each with a plumb-bob at the end." — *The London Illustrated News*, Dec. 14, 1918, p. 786. The device is illustrated in the reference given and also in *Lit. Dig.*, Jan. 11, 1919, p. 18.

argue the toss, to argue the point.

***arrival:** "One first dimly hears the far-off rush of the shell as it approaches, rising in crescendo to a scream and finally terminating by the roar of the burst. This is called an 'arrival'." — Wood, *The Note-Book of an Intelligence Officer*, p. 173. *Compare* Departure.

artillery, beans.

assault ration (Am.), a tablespoonful of rum given to the men in the early morning just before an assault.

atmospherics (Br.N.), the wireless operator or telegraphist. *See also* Angel.

Auzzies, same as Aussies (Australians).

axle-grease, butter; "salve".

B

Baby Killing at a Glance (Br.N.), a designation on British boats for the instruction book given to German submarine commanders; called also "The Huns' Vade Mecum".

Baby tank, a small mobile French tank developed by Louis Renault.

bacon (Am.), army chicken.

balmy, nervous, afraid. This word was used in thieves' cant over a generation ago in the sense of "mad".

barbed-wire disease (Br.), a nervous breakdown. "Turkish officials that have heard the expression translate it literally. Wherefore the Turkish government, in ratifying an agreement with the British for an exchange of prisoners, stipulated that plain wire should be substituted for barbed wire around prison camps for Turks in English territory." — *The New York Times*, May 27, 1918, p. 11.

barn door, soldiers' approximation of *bon jour*.

barndook, a gun, a rifle. The rifle was called also "bundook" and "bondook". These are apparently intermediate stages between "barndook" and "banduc", a Hindustani word which was familiar to the British soldier in India. The nickname "barndook" was used in both British and American armies before the war.

barrel, a stunt of the airman, which consists of rolling the airplane over and over like a barrel. "This is usually started by slightly reducing the speed of the engine, pulling the control stick well towards the pilot, and giving a very quick push at the rudder — to the full extent, in fact — and at once replacing all controls in the center. The machine starts to mount suddenly, but the full effect of the rudder swings the machine up on one wing, over complete sideways, which follows with a wing slip and a flattening sidewise." — *The Scientific American*, Sept. 7, 1918, p. 188.

bashed in, smashed in by a shell.

***bat-boat,** a type of "hydro-biplane in which a large flat boat is fixed beneath the aeroplane proper to float upon water".

Battalion of Death, a battalion of Russian women who tried to avert the Russian disaster. It was organized by Vera Butchkarev, "a peasant woman, who, after her husband had been killed, went to the front herself as a soldier".

beach comber (Am.N.), a tramp or bum that hung around saloons and begged the sailors for money or drinks. He got his name from the fact that he combed the beach for Jack. *See* Ruggles, p. 24.

beached (Br.N.), said of an admiral or a captain dismissed from his command.

beans (Am.), I, the commissary sergeant; II, ammunition.

bean-shooter (Am.), a commissary officer.

belly-robber (Am.N.), an old term for a commissary steward or paymaster whom the crew believed to be robbing them.

Best of luck and God bless you, a parting salutation to men going "over the top".

Betsy the Sniper (Am.), a "155" cannon manned by Americans. "She won her first fame in the Toul sector by being the forward gun of our lines. Not merely was she farthest north, but she scorned the steady brand of firing that most guns of her class indulged in. She went in for emergency sharp-shooting. It was thus that she won the sobriquet of 'sniper'." — *Lit. Dig.*, May 31, 1919, p. 90.

Bevo officers (Am.), new officers; imitation officers; officers who had not gone through West Point. Bevo was one of the new drinks, a near-beer.

***big boys,** large guns, generally eight inches or more.

Big Lizzie, the Queen Elizabeth, so called by the troops at Gallipoli.

Big Push, Battle of the Somme, 1916; called also "Big Show".

Big Show, Battle of the Somme, 1916. *See* Show.

Big Smoke, London. *See* Smoke.

big stuff, large shells, eight inches or over.

big ticket (Am. N.), an honorable discharge. "Small ticket" is a dishonorable discharge.

black boats (Am. N.), destroyers or torpedo-boat destroyers.

black gang (Am. N.), the engineers' division. "Men of the firerooms, engine rooms, ice machine, evaporators, and every man in the department are members of the gang." — Ruggles, p. 24.

Black Guards, *see* Guards.

Black Hawk Division (Am.), the Eighty-sixth Division, composed of troops recruited from northern Illinois. So named because its forces mobilized on the "Black Hawk Trail" at Camp Grant, near Rockford, Ill., and adopted as their battle-cry the war-whoop "Ki-a-ki-ak" of a Black Hawk chief. Insignia, a small monogram "B.H." on a red shield superimposed on a black hawk. The whole is superimposed on a red shield.

black Jack (Am.), I, a strong physic, generally jollop; II, coffee; III, a nickname for General John Pershing, the American commander-in-chief.

***black Marias,** high-explosive shells, a name derived from the slang name for English police-patrol wagons. The following theory is amusing: "One explanation is that a negress called Maria formerly kept a sailors' boarding house in Boston. She was a bit of a terror, and ruled her lodgers with an iron hand. Finally she became so famous that in moments of stress the Boston police gasped: 'Send for Black Maria!'" — *The Detroit Free Press,* June 14, 1925.

black strap (Am.), liquid coffee.

***Black Watch,** I (Br.), the Forty-second Highlanders. "It was while doing duty in Scotland, shortly after the Jacobite uprising, that the Forty-second Highlanders came to be called the 'Black Watch.' The sombre color of the kilts and the work in which they were engaged combined to give them this nickname, which has clung to this famous regiment ever since." — Currie, "*The Red Watch,*" p. 18; II (Am.), the First Battalion of the old Fifteenth New York Regiment.

blackey (Am. N.), the blacksmith.

***Blighty** (Br.), England. This is an Arabic word which was adopted into Hindustani. It means 'foreign country', but as England is the foreign country that has affected India most, it came to mean 'England'. For many years prior to the Great War soldiers in India spoke of going back to Blighty. A Blighty wound was one that caused the sufferer to be sent back to England to recuperate.

Two explanations for this word have appeared in a critical publication. The first contributor writes: "The genesis of 'Blighty' is as follows. From Arabic *walá* (= possess, dominate) come *wáli,* 'governor,' and *wiláyat,* 'government or province of a *wáli.*' In India *wiláyat* has acquired the meaning 'country' in general, and 'foreign country' in particular. Now the country which has most affected India in these latter days is Europe; so in common Indian parlance *wiláyat* = 'Europe,' and especially 'England.' From *wiláyat* is regularly formed the adjective *wiláyati;* in Hindu patois, owing to its preference of *b* to *w, wiláyati* has become *biláti,* and the British soldier has found 'Blighty' more easy to pronounce

than this last. *Voilà tout!*" — *Notes and Queries*, March, 1916, p. 194.

The second explanation is substantially the same: "'Blighty' is the Hindustani *belāti*, as pronounced in the latest dialect of Seven Dials. *Belāti* is the adjectival of *belāt* (*a* broad as in 'art'), which is a form — popular among many Indians — of *wilāyat*, a word originally Arabic and adopted into that composite tongue, the Urdu or Hindustani. The meaning of *wilāyat* is 'a foreign country,' and *wilāyati* (its adjective) means 'foreign.' In common Indian parlance they are particularly applied to England, and thus, when not otherwise qualified, they are accepted as synonymous with 'England' and 'English.'" — *Notes and Queries*, March, 1916, p. 194.

Blighty does not mean, primarily, 'home' and 'over the seas', as some of the popular books on the war state.

Blighty one, a wound that caused a soldier to be sent back to England.

Blighty touch, a slight wound or injury resulting in transfer to a home hospital. Same as "Blighty one".

blimey (or **blimy**) (Br.), a slang term used on any occasion and in any connection, e. g.: "Blimy, I wonder wot they calls livin' 'igh!"

***blimp**, a dirigible balloon from which a car shaped like an airplane fuselage is suspended. It was developed by the British. The word was applied to small airships also.

blimy, same as Blimey.

blind (Am.), sentenced by court-martial to forfeiture of pay without confinement.

blind pig, a huge shell from a trench mortar.

blinds, "duds"; shells which fail to explode.

blister-skin, a broad shelf at the water-line of British monitors, rendering the vessel torpedo-proof. The device is illustrated in *Collier's*, April 5, 1919, p. 15.

blithero, drunk. *See* Drunkenness.

***bloke** (Br.N.), the commander who deals out light punishments.

Bloodbath of the Somme, a German name for the Battle of the Somme.

Blue and Gray Division (Am.), the Twenty-ninth National Guard Division, composed of men from Delaware, the District of Columbia, Maryland, New Jersey and Virginia; obviously so named because the men came from states that fought on different sides in the Civil War. Insignia, a blue and gray pierced disc symbolizing the union of North and South. The insignia is said to have been taken from the Korean symbol of good luck.

***Blue Devils**, Chasseurs Alpins, stocky men from the provinces of France, with picturesque caps and dark-blue coats set off by horizon-blue trousers; said to have been so nicknamed by the Germans.

Blue Funk Squad, the Firing Squad, the duty of which was to execute those guilty of insubordination or cowardice.

Blue Ridge Division (Am.), the Eightieth Division, composed of men from Pennsylvania, Virginia and West Virginia; called also "Lee Division". Insignia, three blue mountains on a shield edged with white. Each mountain represents a state.

boat-tailing: "Modern long-range shells are cigar-shaped. They taper both at the front and at the rear. This tapering of the rear is called 'boat-tailing'. You have noticed that racing automobiles

have torpedo-shaped sterns. A square-tailed shell or automobile is actually held back at high speeds because of the vacuum created behind it by the velocity of its movement. Tapering the tail leads the air gently and easily into the hole that the shell or the racing car bores in the atmosphere and thus lessens vacuum's impeding grip on the flying object." — *Everybody's*, July 1919, p. 72.

bob-tailed (Am.), dishonorably discharged.

***Boche**, a German. Dauzat, the compiler of *L'Argot de la Guerre*, the largest work on French war slang, explains Boche as coming through several intermediate steps from *Allemand*, 'German'. The pejorative form *boche*, which is seen in *caboche*, *rigolboche*, *tête de boche*, etc., was substituted for the last syllable, making *Alleboche*, which wore down to *Alboche* and was finally abridged to *Boche*.

In treating *tête de boche*, he rejects the suggestion of a connection with *bois*, 'wood', but is inclined to favor *tête de caboche*, 'hobnail head', as the origin.

Albert Barrère, *Argot and Slang* (1889), writes as follows: "*Boche* (popular), *rake*, 'rip', 'molrower', or 'beard splitter'. *Tête de boche*, *an expression applied to a dull-witted person.* Literally *wooden head.* Also *a German.*"

Lucien Rigaud, *Dictionnaire d'Argot Moderne*, explains *Boche* (*Tête de*) as meaning hard-headed, dense, or, in the language of the people, *tête de bois*, 'wooden head'. He notes that at Marseilles there is a dialectic word *boche*, which is applied to a ball used in a popular game. It may be added that the Italian word is *boccia*.

The French word *bois* and the Italian *bosco*, both meaning 'wood', may be connected with the low Latin form *buscum*. It has been noted in connection with the sinister meaning of *boche* that the word 'savage' comes from the Latin *silvaticus*, 'man of the woods'. The man from the woods or country has always been the butt of his city cousins.

Another etymology connects *boche* with *caboche*, a hobnail with a hard, rough and square head. It has also been regarded as a 'back-slang' corruption of *Schwob*, 'the Alsatian slang term for his German master'.

A more detailed etymology has been suggested: "*Boche* is an abbreviation of *caboche*, (compare *bochon*, an abbreviation of *cabochon*.) This is a recognized French word used familiarly for 'head', especially a big, thick head, ('slow-pate'.) It is derived from the Latin word '*caput*' and the suffix '*-oceus*'. *Boche* seems to have been used first in the underworld of Paris about 1860, with the meaning of a disagreeable, troublesome fellow. In the Franco-Prussian war of 1870 it was not applied to the Germans, but soon afterward it was applied by the Parisian printers to their German assistants because of the reputed slowness of comprehension of these foreign printers. The epithet then used was *tête de boche*, which had the meaning of *tête carrée d'Allemand.* The next step was to apply *Boche* to Germans in general." — D. L. Buffum, *Current History*, 7.525.

See also Smith, pp. 24–27.

boko, an Atkinized form of the French *beaucoup*, 'much'.

Bolsheviki, 'Majoritarians'. "Russians tell us that by derivation the word means 'those of the majority', referring to a bygone

schism in one of the revolutionary parties under the old Tsardom." — *The Independent*, Nov. 24, 1917, p. 357. In 1898 there was organized in Russia a Social Democratic Party. After the failure of the revolutionary movement in 1905, the radical faction, which insisted upon a purely working-class movement, commanded a majority, and hence arose the name Bolsheviki. The less radical party became the Menshiviki, 'Minoritarians'. See *The Independent*, July 20, 1918, p. 102.

bombs, nicknames for (Br.): "The 'hairbrush', the 'lemon bomb', the 'cricket ball', and the 'policeman's truncheon' were the most important of these, all of them so-called because of their resemblance to the articles for which they were named. The first three were exploded by a time-fuse set for from three to five seconds. The fourth was a percussion bomb, which had long cloth streamers fastened to the handle to insure greater accuracy in throwing. The men became remarkably accurate at a distance of thirty to forty yards. Old cricketers were especially good, for the bomb must be thrown overhand, with a full-arm movement." — J. N. Hall, *Kitchener's Mob*, pp. 132–133.

***bonza**, good. This word is said to be the French *bon*, 'good', with the Spanish suffix *-za*.

boot (Am. N.), "a young sailor who has recently enlisted in the navy; a man who is exceedingly wooden in the performance of his duties and who is uncouth in his habits." — Ruggles, p. 25.

boot-lace, an airman's term to describe a sort of combined spin and roll.

Bosche, evidently an unconscious attempt to Germanize the word Boche.

bottles (Br. N.), air-tanks in submarines.

***bounce**, a bad landing causing the airplane to jump. It was often the cause of a crash.

bouquet, a group or cluster of shells or bombs.

bow-legs (Am.), cavalrymen.

Brain Trust (Am.), the General Staff.

brains, the intelligence officer.

brass looie (Am.), lieutenant.

bread pudding with whiskers, a pudding in which the 'whiskers' were explained as shreds from the gunny sack.

***brig**, prison; called also 'cage', 'jug', 'cooler'.

Bristol Bullet, a common name for the British scout machine, a product of the British and Colonial Aeroplane Company of Bristol.

Broad Arrow Division (Am.), the Thirty-second Division, composed of troops from Michigan and Wisconsin. Insignia, a red arrow, because "they shot through every line". "To the army in general it is the Thirty-second, to the people of Michigan and Wisconsin, it is the *Broad Arrow Division*, while the French will always remember it by the name given to it by the poilus, *Les Terribles*." — *The New York Times*, May 18, 1919, § 4, p. 7. It is called also "Iron Jaw" because it was employed on both flanks of the Marne salient.

broom-stick, the control lever of airplanes.

Brunhilde, same as Brünnhilde. *See* Hindenburg Line.

***bubbly**, champagne.

bucked, proud or pleased.

Buckeye Division (Am.), the Thirty-seventh Division, made up ex-

clusively of National Guardsmen from Ohio. The nickname was adopted in November, 1917. Insignia, a red circle superimposed on a white circle, a design adapted from the Ohio flag.

The National Geographic Magazine, Dec., 1919, p. 518, says that this division contained troops from West Virginia also.

buck-private (Am.), a term sometimes used in speaking of a private.

***buckshee**, free; faked; surreptitious, such as a 'buckshee pass'; extra; surplus, such as a 'buckshee helping'; smart; superfine, e.g., as regards clothes. Buckshee is an Atkinized form of an Indian word. "*Bakhsh* is a gift; *bakhshi* is the giver, paymaster; *bakhshish* is a gift, a tip. All these ideas seem to have had a hand in making 'buckshee' to mean something extra." — *Notes and Queries*, Dec., 1918, p. 333.

Buffalo, a Sopwith airplane designed for reconnaissance and contact patrol work.

Buffaloes (Am.), members of the Ninety-second Division, composed of Negro troops from various sections of the country. Insignia, a black buffalo on a disc. It is said that the name goes back to pioneer days when Negro soldiers were called upon to aid in suppressing Indian uprisings. The redskins, learning to respect them as soldiers, nicknamed them 'Buffaloes'. The title is inherited from the 367th Regiment of the 15th New York (colored) Infantry, which was incorporated in the division.

The color of the buffalo varied according to the arm of the service.

Buffs (Br.), the East Kents.

bug-house, a dugout.

bug-trap (Br.N.), a gun-boat.

bull (Am.N.), small talk; "mean brand of chatter".

"Bull" Allenby (Br.), General Allenby, the captor of Jerusalem.

[1]**bull ring**: "Just before going into the trenches the British, French and American troops take a final course for a few weeks in a training school, where the expert drill masters put them through a rigorous discipline, and the finishing touches are given to each regiment. . . . The men commonly call this training school, or specially prepared final drill ground, the 'Bull Ring'." — S. Eddy, *With our Soldiers in France*, p. 45.

[2]**bull ring** (Am.N.), a 'hanging-out' place on many of the large cruisers and battleships. "It is situated on the main deck forward just under the conning tower and at the base of the cage mast."—Ruggles, p. 22.

***Bullet**, a Bristol biplane.

bullets, beans.

bullocky's joy, merely molasses or 'golden syrup'; at times called also 'cocky's delight'.

Bull's-eye Division (Am.), the Thirty-ninth Division, composed of troops from Arkansas, Louisiana and Mississippi. On Feb. 23, 1919, *The New York Times* described the insignia as an inner circle of red, a middle one of white, and an outer circle of black. *The National Geographic Magazine* for Dec., 1919, p. 513, gives the insignia as a delta enclosing three small deltas, but says, p. 518, that it was never approved by the A. E. F. The insignia was due, of course, to the fact that the personnel came from the vicinity of the delta of the Mississippi.

bumboats (Am.N.), a name given to hawkers and peddlers aboard ship.

bumped off, killed.

bumps, fleecy white clouds which

caused an airplane to give a slight jar or quiver; irregularities in the atmosphere; jars caused by dropping down into an air-pocket. "Bumps of 250 feet have been experienced several times, which means that the aviator has dropped into an air-pocket, and slid down the emptiness so quickly that the effect of reaching normal conditions again has given an awful bump, in much the same way as a man jumping from a wall feels the jar when he hits the solid ground below." — E. Wood, *Thrilling Deeds of British Airmen*, p. 77.

bunk, bed.

bunk lizard (Am.N.), a chronic sleeper.

***bunker plates** (Am.N.), hot cakes, flapjacks and pan-cakes. They were so called because of their resemblance to the lids of coal chutes.

bunkie, sleeping companion.

Burleson magazines (Am.), periodicals contributed by the public to the Army and Navy and forwarded to them by the Post-Office Department. The name was due to the fact that Postmaster-General Burleson authorized the postal force to forward these magazines and periodicals under a one-cent stamp.

Burney gears (Br.N.), paravanes, so named after the inventor, Commander Burney, of the British Navy.

***bus,** I, a flying machine; II, a tank.

bust (Am.), to reduce a non-commissioned officer to the grade of private.

butcher (Am.), the company barber.

butcher shop, the operating room; the surgical department.

buying white horses (Br.N.), wasting money ashore in wanton extravagance. "White horses" is a very old nautical term for the endless waves curling over and breaking into masses of foaming water.

C

caboosh: "'The whole caboosh' means the whole show, all of it, 'lock, stock and barrel'." — Nettleinghame, *More Tommy's Tunes*, p. 95.

Cactus Division (Am.), the Eighteenth Division, which was organized at Camp Travis, Texas, in August, 1918. Insignia, a cactus, with the Latin motto, *Noli me tangere*, 'Don't touch me'.

cadge, to borrow.

Café Adelaide, a vernacularized form of the French, *café au lait*, 'coffee with milk'.

cage, wire enclosure for prisoners.

calicoes, girls.

Camel, *see* Names for airplanes.

camel flags, a popular pronunciation of camouflage.

***camouflage,** the art of concealing. A French slang dictionary says that *se camoufler* is thieves' cant meaning 'to disguise one's self'. The word was employed by soldier and civilian alike to indicate any form of concealment.

can, an airplane.

Can the Kaiser (Am.), a popular slogan of the American army. One of the soldier songs runs as follows:

"We're off to can the Kaiser,
Hooray! Hooray!
In Kaiserland we'll take our stand
Until we can the Kaiser.
Let's go, let's go, let's go and can the Kaiser!
Let's go, let's go, let's go and can the Kaiser!"

Canada, a Canadian name for No Man's Land.

Canary cruisers (Am.), a name used by Americans on escort duty at the Azores to designate German submarines which used the Canary Islands as a supply base.

candidate for gold bars, an aspirant for a second lieutenantcy.

canned horse (Am.), canned beef.

***cannon fodder,** soldiers regarded as food for cannon. The Germans were fond of this expression at the beginning of the war when their superior equipment gave them a tremendous advantage.

cartwheel, one of the acrobatic stunts of the airman.

Casey, Knights of Columbus. The name was abbreviated to K.C., the pronunciation of which suggested the name Casey.

caterpillar, an engine or tractor that drew big guns.

ceiling work, the protection by an airman at high altitude of planes below.

Cela ne Fairy Ann, that's all right. *See* Sandbag Mary Ann.

***chancing his arm,** the army's condemnation of one who has been telling a far-fetched story.

chancing his mit, same as Chancing his arm.

Charlie, infantryman's pack.

Charlie Chaplin's Army Corps, a clearing house for Canadian casualties.

chasing prisoners (Am.), guarding prisoners employed at labor.

chello, get out of the way.

chevaux-de-frise ("Frisian horses"), barbed-wire defences against cavalry.

Chevy Chase, *see* Rhyming slang.

chief (Am.), the chief musician of a band.

Chinese show, *see* Show.

Chinese Wall, part of the Hindenburg Line in the region of Villeret.

***chippies,** carpenters in the British naval air-service.

chocolate soldiers, a brigade of Australians. "They received this nickname because they were the most completely equipped unit that ever left Australia. They were commanded by a well-known public man, and the womenfolk had seen that they lacked nothing in sweaters or bed socks." — Knyvett, *"Over There" with the Australians*, p. 153.

chow, food; "eats". The word is used as a verb also. The soldier and sailor use of this word has been laid at the door of the Chinese chow dog, which has a reputation for insatiable hunger.

chow slang, examples of (Am.N.), "punk", bread; "sand", sugar; "sea dust", salt; "axle-grease", butter; "Java", coffee; "lachie" (Spanish), milk; "gas bombs," eggs; "snake eyes", tapioca; "repeaters", sausages; "fowl balls", chicken croquettes; "submarine shark", salmon. See Ruggles, p. 20.

"Lachie"is a phonetic representation of *leche*.

***chuck a dummy,** to be absent.

chuppaties, a kind of oaten pancake.

cigarette maker, a Turk. *See* Abdul Pasha.

Clark (Br.N.), Nobby. "On the Lower-deck if you are a Clark, it is the traditional surname of 'Nobby' that you get; if Green, 'Shiner'; Martin, 'Pincher'; Miller, 'Dusty'; Wright or White, 'Shiner' or 'Shiney'; Bennet, 'Wiggy'; Harris, 'Chats'; and so on through a great number of surnames." — Vaux, p. 57.

cleaning tricks (Br.N.), turns at cleaning and polishing. See Vaux, p. 59.

Clew up (Br.N.), cease talking; "pipe down".

***click,** to die; to be killed; to kill;

to draw some job, agreeable or disagreeable. "To click can be either advantageous or baneful, according to the circumstances. A soldier asks a superior for a favor, and it is granted. That soldier has clicked. . . . Or if he is given a coveted post, he has clicked. But he has also clicked if he is suddenly seized on to do some menial duty. He has clicked if he is discovered in a misdeed. And he has clicked a packet if he gets into trouble generally." — Muir, pp. 226–227.

climbin' the riggin' (Br.N.), being angry.

***clink**, guardhouse. "Lock-up or gaol was always 'clink' in the vernacular in South Devon when I was a boy nearly 70 years ago. 'I'll 'ave 'ee put in clink' is a threat I often had shouted at me when a small boy bent on mischief." — W. C. Forman, *Notes and Queries*, Dec., 1918, p. 333.

clinker-knotters (Br.N.), stokers.

clock, one's face.

cloud fly, a French baby monoplane.

Cloverleaf Division (Am.), the Eighty-eighth Division, composed of troops from Iowa, Illinois, Minnesota and North Dakota. Insignia, a black four-leaf clover. There is a loop for each state. The insignia was evolved by placing two figure 8's at right angles.

Clown Prince, the Crown Prince.

coal-scuttles, German helmets.

cochon, "pig", a term applied to Germans by Belgians especially.

cocky's delight, molasses.

coffin o' sharks (Br.N.), a tin of sardines.

cole, a penny.

comb out, to search the industries for material available for soldiers.

Come aboard and make your number (Br.N.), come aboard and send in your name. Upon arriving at a port or joining a flag, ships announce their identity by "making their number"; hence the origin of the phrase.

Come in at the hawse hole (Br.N.), to join the navy as an ordinary seaman. Jack Tar would use this expression to describe one who had started at the bottom and climbed upward.

come-alongs, strands of barbed wire about three feet long made into nooses; used by raiding parties to induce Fritz to "come along".

***Comic Cuts**, the name by which the daily G. H. Q. summary was known; called also Daily Liar.

coming it, trying to outwit or "put something over".

coming the acid, boasting; lying about something.

commissaries (Am.), groceries.

Compray, Atkinized French meaning "Do you understand?"

conked: "A new word which is taken from the Russian language and which means stopped or killed." — E. M. Roberts, *A Flying Fighter*, p. 334.

Cook's Tourists: "These individuals were officers sent over from the Canadian Training Base for short periods of one or two months to receive instruction in trench warfare. Incidentally they brought with them some wondrous ideas about the proper methods of doing things, gathered from some official publications known as 'Notes from the Front', and were greatly surprised to find we were not in touch with this 'trade' journal." — F. C. Curry, *From the St. Lawrence to the Yser*, p. 155. *See* "Cook's Tour", in Fraser and Gibbons.

cootie carnival, search for cooties; better known as a "shirt hunt".

cop it, to be struck by a missile.

copped it, airman's slang meaning to be picked out for some duty.

corkscrew, a kind of spiral dive by an airplane.

corned Willy, canned beef.

cosmoline soldiers, heavy artillery; so called from the oil used on the guns.

cottage (Br.N.), the mess.

cove, the commanding officer. "'Cove', a fellow, a man, a person, is from the Celtic or Keltic *caobh* — *bh* pronounced as *v* — which signifies courteous, and is synonymous with the vulgar abbreviation of 'gent' for gentleman." — C. Mackay, *Blackwood's Magazine*, Vol. 143, p. 693.

cow (Am.), milk.

crasher, violent landing of an airplane brought down by shell-fire.

***crawl** (Am.), to admonish.

crawling, buying favors.

cream puffs, airman's term for spherical clouds of white smoke caused by bursting shells.

creeper, *see* Grass-cutter.

creeping Jimmy, a high-velocity shell which gave no warning of its approach.

***cricket ball,** the name given to a bomb of the shape and size of a cricket ball. *See* Bombs.

crock, a soldier who is disabled for life.

crocked, disabled.

crow (Am.N.): "The rating badges of the service have an eagle spread over the designated insignia of the wearer and when a man gets rated, it is said that he got the crow — buzzard, bird or hawk." — Ruggles, p. 38.

Crown and Anchor, a dice game much played in the trenches. "The paraphernalia used in 'Crown and Anchor' consists of a piece of canvas two feet by three feet. This is divided into six equal squares. In these squares are painted a club, diamond, heart, spade, crown, and an anchor, one device to a square. There are three dice used, each dice (*sic*) marked the same as the canvas. The banker sets up his gambling outfit in the corner of a billet, and starts ballyhooing until a crowd of Tommies gather around; then the game starts. The Tommies place bets on the squares, the crown or anchor being played the most. The banker then rolls his three dice and collects or pays as the case may be. If you play the crown and one shows up on the dice, you get even money; if two show up, you receive two to one; and if three, three to one. If the crown does not appear, and you have bet on it, you lose, and so on. The percentage for the banker is large if every square is played, but if the crowd is partial to, say two squares, he has to trust to luck. The banker generally wins." — Empey, *Over the Top*, pp. 145–146. The game is described at greater length by S. Graham, *A Private in the Guards*, pp. 185–187.

***crump,** an onomatopoetic name for a shell which burst with a cr-r-r-rump. The word was used as a verb also: e.g., "At one time the Hun used to 'crump' Bethune daily with the greatest regularity." "Crump is the general name for high-explosive shells of from 4.1 up, but the commonest size is the 5.9 or 150 mm." — McBride, *The Emma Gees*, p. 88.

crumper, a large shell.

Cuckoo, I, a Sopwith airplane; II, an airman that did his fighting with his mouth.

cuff leggins (Am.), puttees.

***cum shaw** (Am.N.): "The Chinese merchant's name for come ashore. When he tells you to come ashore,

it means to kick loose or come across." — Ruggles, p. 33. The expression is used also to indicate the receipt of a bribe or graft.

cum-sah (or **U-jah**), the equivalent of "What's its name?" The word is a vernacularized form of the French, *Comme ça.*

curtain of fire, a wall of fire; a barrage; shells falling in a vertical plane and designed to prevent the enemy from escaping or from bringing up men or supplies.

cushie, *see* Cushy.

cushty, smart, good.

***cushy,** "a slight clean wound, that does not permanently injure, and still gives the sufferer the honor and glory of having been wounded. This again seems to be soldiers' Hindustani from a Persian adjective *khush* (or strictly *khwush*), pleasing, pleasant, through a derived noun *khushi*, pleasure, pleasantness, commonly pronounced by Europeans 'cooshy', the *oo* short and accentuated." — *Notes and Queries,* April, 1916, p. 292.

cushy Blighty, a slight wound that caused a soldier to be sent back to England.

cushy one, a slight wound.

cushy wound, same as 'Cushy one'.

Custer Division (Am.), the Eighty-fifth Division. "When the 85th Division was stationed at Camp Custer, Michigan, there was a long discussion over a suitable nickname for the outfit. Such names as Wolf, Badger, Buck, Lynx, Grizzly, Eagle, Wolverine, Brown Devils, Invincibles, Iron Ore, Lightning and Great Lakes were suggested and discarded on the ground that they were not distinctive. It was finally christened the 'Custer Division'. At first this division was made up solely of men from Michigan and Wisconsin, but later guardsmen from Kentucky, Indiana and Illinois were transferred to it." — *The New York Times,* Dec. 29, 1918, § 4, p. 8. Insignia, initials "C. D." in red.

Cyclone Division (Am.), the Thirty-eighth Division, composed of troops from Indiana and Kentucky. Insignia, "CY" on a blue and red shield.

D

Daily Liar, *see* Comic Cuts.

Daily News (Am.), latrine rumors. In very cold weather the latrine was the warmest place to be found, since it contained a large boiler to heat water for the showers. The warm spots near the boiler were the center of camp gossip.

***daisy root,** *see* Rhyming slang.

darkening the ship, *see* Sick Bay Express.

dazzle camouflage, the use of patches of color and of stripes to break up the characteristic outlines of a ship.

dead soldier (Am.N.), an empty beer bottle; "dead dog".

dead west (Br.N.), close-fisted.

dead-leaf fall, an airman's stunt.

death-bomb, depth-charge; compare Tommy's 'Rout-march' for 'Route-march'.

decks, the wings of an airplane.

Deedonc (Am.), Frenchman. See Smith, s. v. Didonk, pp. 55–56.

deep sea turkey, salmon.

departure: "When a shell starts from one of our own guns, one hears first the crash of the discharge, followed in diminuendo by the noise of the shell progressing farther and farther towards the enemy. This is called a 'departure'." — Wood, *The Note-*

Book of an Intelligence Officer, p. 172. *See* Arrival.

depth bombs. (Am.N.), eggs. *See* Chow slang.

Der Tag ("To the Day"), a frequent pre-bellum German toast, very common in the navy. It had reference to THE DAY when Germany should throw off the shackles of peace and begin her divinely appointed mission of (mis-)ruling the world.

Der uffs (*Deux oeufs*), Tommy's French for "two eggs".

Desk hooks (Am.), spurs, an expression employed in the air-service, because the only use an officer had for spurs was to keep his feet from sliding off the desk.

Devil Dogs (Germ. *Teufelshunde*), a German nickname for the U. S. Marines.

Devil eggs, mines.

Devil-dodger (Br.N.), the chaplain.

Devil's Strip, No Man's Land.

Dexie and Billy: "If it is an English trench at least four people will be bending over what they call a 'Dexie', and if an Australian trench, what they call a 'Billy', making tea." — Macquarrie, *How to Live at the Front*, p. 123. *See* Dixie.

***dig-in,** a small excavation.

***dipped,** an expressive word for being torpedoed at sea. In the British navy the term means also, "to receive a set-back"; to "get ditched".

Dirty Little Imps (Br.), a parody on Durham Light Infantry.

Divisions, names for American (Am.): Ace of Diamonds, Fifth; Acorn, Eighty-seventh; Alamo, Ninetieth; All American, Eighty-second; Black Hawk, Eighty-sixth; Blue and Gray, Twenty-ninth; Blue Ridge, Eightieth; Broad Arrow, Thirty-second; Buckeye, Thirty-seventh; Buffaloes, Ninety-second; Bull's-eye, Thirty-ninth; Cactus, Eighteenth; Cloverleaf, Eighty-eighth; Custer, Eighty-fifth; Cyclone, Thirty-eighth; Dixie, Thirty-first; Empire, Twenty-seventh; Illinois, Thirty-third; Indian Head, Second; Iron, Twenty-eighth; Iron Jaw, Thirty-second; Ivy, Fourth; Jayhawkers, Eighty-ninth; Jersey Lightnings, Seventy-eighth; Keystone, Twenty-eighth; Lafayette, Eleventh; Lee, Eightieth; Les Terribles, Thirty-second; Liberty, Seventy-seventh; Lightning, Seventy-eighth; Lincoln, Eighty-fourth; Lone Star, Thirty-sixth; Marne, Third; Melting-pot, Seventy-seventh; Metropolitan, Seventy-seventh; Middle West, Eighty-ninth; New England, Twenty-sixth; New York, Twenty-seventh; New York's Own, Twenty-seventh and Seventy-seventh; Old Hickory, Thirtieth; Panther, Thirty-sixth; Pathfinder, Eighth; Pennsylvania, Twenty-eighth; Plymouth, Twelfth; Prairie, Thirty-third; Rainbow, Forty-second; Red Diamond, Fifth; Sandstorm, Thirty-fourth; Sight-seeing Sixth, Sixth; Sunset, Forty-first; Sunshine, Fortieth; Upton, Seventy-seventh; Western, Eighty-ninth; Wild Cat, Eighty-first; Wolverine, Fourteenth; Wild West, Ninety-first; Yankee, Twenty-sixth; Yellow Cross, Thirty-third.

Some divisions have two or more names: e.g., the Twenty-sixth, New England, Yankee; the Twenty-seventh, Empire, New York, New York's Own; the Twenty-Eighth, Iron, Keystone, Pennsylvania; the Thirtieth, Wild Cat (by mistake), Old Hickory; the Thirty-second, Broad Arrow, Iron Jaw, Les Terribles; the Thirty-third, Illinois, Prairie, Yel-

low Cross; the Seventy-seventh, Liberty, Melting-pot, Metropolitan, New York's Own, Upton; the Seventy-eighth, Lightnings, Jersey Lightnings; the Eightieth, Blue Ridge, Lee; the Eighty-ninth, Jayhawkers, Western, Middle West.

Further information is given about these nicknames in their alphabetical positions.

***Dixie:** "an iron box or pot, oblong in shape, capacity about four or five gallons. It fits into the field kitchen and is used for roasts, stews, char, or anything else. The cover serves to cook bacon in." — Holmes, p. 52. Strictly speaking, this is not slang. The cooking-pots issued by the Army Ordnance Corps are officially designated as Dixies, though no one seems to know why.

Dixie Division (Am.), the Thirty-first Division, N. G., composed of men from Alabama, Florida and Georgia. Insignia, the letters "GD" in red enclosed in a red rim.

dizzies, island-like pieces of ground surrounded by communicating trenches.

do a tap (Br.N.), to grumble. The army equivalent is "grouse".

do in, to kill.

***Dodger** (Br.N.), a standard nickname for any man named Green. In the same way "Nobby" designates a Clark or Clarke and "Pincher" a Martin.

dodger, a gas cylinder.

dog tag (Am.), identification disc.

dog tent (Am.), a small shelter tent.

***dog-biscuits** (Br.): "Rations were served out at nine o'clock, every man getting four biscuits (*dog-biscuits* the men christened them), hard as iron almost and not very palatable; but it is stated that one gets used to these and enjoys them greatly in the course of time." — P. MacGill, *The Red Horizon*, p. 15.

doggo, still; quiet. The word is said to be of East Indian derivation.

dogs (Am.), the marines' name for "feet".

***Dolphin,** *see* Names for airplanes.

Dominion of Canada, No Man's Land. *See* Kings of No Man's Land.

Donkey's Head, a height in the center of the Argonne Forest, so called by the French at the outset of the war.

doosel (from the French *du sel*), salt.

dose of three-o-three: "To get wounded with one of our own bullets was to get a 'dose of three-o three'. The bullet has a diameter of three-hundred-and-three thousandths of an inch." — J. Gallishaw, *Trenching at Gallipoli*, p. 136.

doss, sleep; to sleep. This word has long been used in thieves' cant and elsewhere. It was formerly spelt *dorse*. Perhaps it is from the phrase, "to lie on one's dorsum". *Dorsum* is Latin for "back".

dough boys (Am.N.), bakers.

***doughboy:** The following are the two earliest uses of the word as given in the Oxford Dictionary:

"1685 Ringrose *Bucaniers Amer.* II, iv. 4 These . . . men had each of them three or four Cakes of bread (called by the English *Dough-boy's*) for their provision and victuals.

"1697 Dampier *Voy.* (1729) I. v. 110 This oil served instead of Butter, to eat with Dough-boys or Dumplins."

The following paragraph is from Thornton, *An American Glossary:*

"Wasn't I glad I was not a

doughboy!" — Letter of General Custer, March 28. (Note.) A *doughboy* is a small round doughnut served to sailors on shipboard, generally with hash. Early in the civil war, the term was applied to the large globular brass buttons of the infantry uniform, from which it passed by natural transition to the infantrymen themselves. — Mrs. Custer, 'Tenting on the Plains,' p. 516 (1888)."

The term doughboy is now applied to the infantrymen only, e.g.,

The cavalry and artillery
And the lousy engineers,
They couldn't lick the doughboys
In a hundred thousand years.

Etymologies are as numerous as authorities:

A correspondent of *The New York Times* writes under the date of Oct. 13, 1918 (editorial section, p. 2): "I have known of the term 'doughboy' as applied to infantry soldiers for 70 years; it did not originate in the civil war, but was in use long before in the British Army."

"I believe that the name comes from a Spanish word, and was given by the American cavalry to the infantry during the old war in Mexico, because the infantry were usually covered with dust." — *Notes and Queries*, Oct., 1918, p. 271, quoting Colonel Repington, *The Morning Post*, Oct. 5, 1918.

"Another story has it that during some maneuvers in Texas an artilleryman, comfortably perched on a gun, saw a soldier hiking in the thick sticky Texas mud. The mud was up to the shoetops of the infantryman and the upper part which had dried looked almost white. 'Say,' shouted the artilleryman, 'what've you been doing? Walking in dough?' And so the men who march have been doughboys ever since." — Heywood Broun, *The A. E. F.*, p. 40.

"Fifty or sixty years ago Richard Bedford Poulden, late of the 56th Regiment, distinguished himself in Australia by the capture of a powerful aboriginal murderer named Doughboy. Probably the name was given to that individual in the days of his innocence, and from his own, and not his buttons', resemblance to a dumpling." — *Notes and Queries*, Nov., 1918, p. 307.

Four popular explanations of the origin of the word are quoted by George H. McKnight, *English Words and Their Background*, p. 349.

dough-puncher (Am.), the baker.

dovetails: "We were attending the Artillery School at Saumur, France, when the armistice was signed. An order was received from Washington to the effect that no more commissions would be granted. But we had to finish the course of training. We were sure S.O.L. ['Strictly out of Luck'.] Later the order was modified to the effect that we would be commissioned in the U.S.R. upon discharge in the States. But between graduation in France and discharge in the States, we have no standing. We are supposed to fit in some place between a buck private and a 'Shavetail', so some bright bird christened us 'Dovetails' or 'Third Lieutenants', and the name has stuck, and as such we are known around our outfits." — *Lit. Dig.* April 19, 1919, p. 107.

down for a shoot (Am.N.), having to appear at the mast before the

captain; same as "down for a chance", "up for a shot".

dozey, dull; slow.

dream sack (Am.N.), the hammock.

drum-fire, artillery fire so intense that the successive shots merge into one another, suggesting the roll of a drum.

drum-up: "I've got some sugar. If you get tea and hot water, we'll have a 'drum-up'." — *Notes and Queries,* Jan., 1919, p. 19.

drunkenness: "The words for drunkenness are innumerable — 'jingled', 'oiled', 'tanked to the wide', 'well sprung', 'up the pole', 'blotto', etc." — Muir, p. 230.

dry battle, a battle in which there was comparatively little bloodshed. The word has been used of the Battle of San Mihiel.

dry-land sailors, reservist seamen, stokers, marines, and naval volunteers organized by Winston Churchill for land fighting. To the Army they were known as "so-called salts".

ducks, urinals; "submarines".

duck-walk, a slatted wooden walk built to prevent soldiers from sinking into the mud.

***dud,** an unexploded shell. The term was extended, however, to apply to anything bad or unfavorable, even to persons. This idea was doubtless suggested by the use of the word to mean ragged and worthless clothes. The word was employed occasionally, however, before the war in speaking contemptuously of a person.

"Some ready witted Tommy addressed himself one day to a huge German shell that had fallen near him but failed to explode. 'You dear old dud', beamed the Tommy. Since then all harmless shells, bombs or cartridges have been known as 'duds'.

"From explosives that do not explode, the word soon extended itself in fighters' vocabularies to describe idle parts of the front as 'dud sectors', war weary Boches as 'dud Fritzes', and battles that fail to develop into expected big actions as 'dud shows'." — *The Stars and Stripes,* Feb. 15, 1918, p. 3.

dumdums (Am. ambulance), beans.

dummy compass, "a card upon which the circle of the horizon is marked off in sectors like the pieces of a pie". Upon this embryo seamen practised until every sector of the horizon acquired a definite meaning and location. See R. D. Paine, *The Fighting Fleets,* p. 389.

***dumps,** "the colloquial word designating the points where the wagons and motor transports deposit ammunition, food and other trench stores, and whence they are carried up to the front line by the men". — McBride, *The Emma Gees,* p. 43.

dupan (Fr. *du pain*), bread.

dust-disturbers (Am.), the infantry. *See* Names for infantry.

E

Easter Egg Flotilla (Am.), the small boats of the Patrol Squadron in European waters. The name was doubtless suggested by the nestful of "eggs", or depth-bombs, that each of these little boats carried ready to drop over the stern. *Compare* Suicide Fleet.

***egg,** I, a bomb; II, a mine; III, a depth charge; IV, a new airman; V, a new member of the Gimper Squadron, q.v.

egg basket, a tin arrangement by

which bombs were carried in airplanes.

eighteen-pounders, an affectionate name for under-age recruits.

***elephant,** an observation balloon with blunt jutting wings on either side and a protuberance beneath, which suggest exaggerated ears and a proboscis.

elephant backs, pieces of iron to serve as roofs for "elephant dugouts".

***elephant dugout,** a large, safe and roomy dugout, braced by heavy steel ribs or girders.

elephant rifle, a German anti-tank rifle.

Elsie, a fine inflicted by a Summary Court Martial, e.g., "A five-dollar Elsie", "A ten-dollar Elsie".

***embuss** and **debuss,** to get in and out of a motor-omnibus.

Empire Division (Am.), the Twenty-seventh Division, composed of men from New York; called also New York's Own". Insignia, the letters "NY" in a red monogram on a black field with the constellation of Orion. The constellation is a pun on the name of the commander, Major-General O'Ryan. *See* Hobnail Express.

evening hate, a German cannonade, which at one time was a regular evening performance.

exemption (Am.), an ailment, real or simulated (generally simulated), by which a man hoped to be exempted from duty. Confirmed "invalids" of this type were greeted in the morning with the salutation, "Full of exemption again?"

eye, periscope.

***eye-wash,** getting ready for inspection; making things outwardly presentable. "It is apparently used to denote anything that is exaggerated or calculated to deceive or mislead. Any portion of an official document, or a list of regulations which is not of vital importance, is designated 'eye-wash'. So also are complimentary remarks, either true or otherwise." — *Notes and Queries*, Jan., 1919, p. 19.

Another writer says that the term is "applied to most circular memoranda received, particularly about wearing of slacks or Sam Brownes, saluting, or economization of petrol; something to be winked at".

F

face like a scrubbed hammock (Br.N.), a dejected facial expression.

face like a sea-boot (Br.N.), a dejected or wry facial expression.

fag, a cigarette. The cigarette became a trench necessity. "If yer can't give me a fag, light one and let me look at it burnin'." — P. MacGill, *The Red Horizon*, p. 190.

faker's palace (Am.N.), the ship's hospital; "sick bay".

false alarm, *see* Rhyming slang.

Fannie, a Dixie or boiler.

fast freights, heavy shells.

fatigews, men detailed for fatigue or routine drudgery.

***feather,** the wake or ripple left by a protruding periscope. The "feather" was often visible when the periscope was not. For a good picture of a "feather", see *World's Work*, Oct., 1919, p. 609.

***fed up,** sated; disgusted; got enough of it. A contributor to *Notes and Queries* for March, 1919, p. 79, states very guardedly that he thinks the expression was picked up from the Australian troops in the Boer war of 1899–1902.

***female tanks,** *see* Male tanks.

figgy duff (Br.N.), plum-pudding.

file (Am.), a number on the lineal list.

first hitch (Am.), first enlistment. *See* Hitch.

fish, I, torpedo; II (Am.N.), a dirigible balloon; III, a submarine; IV, a man who could not fly.

fish tails, grenades embracing everything from the small "pineapples", fired from the rifle, to monstrous aërial torpedoes. They got their name from a kind of vane or rudder which served to guide the projectile in its flight.

fix, the location or position of a submarine as established by listening devices. For the method of establishing a "fix," see Sims, *World's Work*, March, 1920, pp. 458–459. Cf. *Ibid.*, Feb., 1920, p. 368.

fizz-bang, a shell.

flags, a signaller.

flag-wagger, a signaller.

***flaming onions:** "These 'flaming onions' were huge rockets of balls of phosphorus which burst at the top of their climb and spread out into a great umbrella-shaped curtain of flame, and sank slowly down, the idea being that any machine in its path would be instantly set fire to by the burning phosphorus." — V. Drake, *Above the Battle*, p. 118.

Another account describes them as "a type of small incendiary shell fastened together in chains by wire. If such a shot finds a target, it winds round the object and creates a fire". — *The Mail* (London), April 29, 1918, p. 1.

flare, a rocket fired at night from a pistol to light up No Man's Land; the blaze of light from star-shells.

flea-bag, officer's sleeping bag.

flipper, hand.

fly class, a designation for a number of fast shallow-draught and heavily armed boats specially designed for use on the Tigris. They were sent overland in parts and assembled on the spot.

fly traps, wire entanglements.

flying fish, I, rifle grenades; II (Am.), planes in the naval air service.

flying fish hooks, hooks attached to fire-balls by Germans to make sure of burning up planes in case contact was made.

flying tanks, armor-plated scout planes.

flying turtle, the French observation balloon; same as Sausage.

for the duration, for the duration of the war. A soldier might speak of having enlisted "for the duration".

for the jumps, destined to stand trial for an offence.

found (Am.), to be found deficient or wanting in anything, especially in an examination.

fowl balls (Am.N.), chicken croquettes. *See* Chow slang.

fox holes, individual excavations to serve as shelters or dugouts.

Fox of the Balkans, the former King Ferdinand of Bulgaria.

***free gangway** (Br.N.), the way is open to all.

freeze, to lie perfectly flat on the ground while rockets are breaking in No Man's Land.

Freia, same as Freya. *See* Hindenburg Line.

***Fritz,** a German. *See* Names for Germans. German submarines were sometimes called Fritzes.

Frogs, Frenchmen.

fug: "A smoke-fire fog, usually applied in a dugout, where ventilation is at a premium, and a brazier or army stove is well made-up. The result being a hot, stifling, smoky and visible atmosphere, known as a 'real fug'." — Nettleinghame, *More Tommy's Tunes*, p. 95.

G

G.I. cans, German heavy shells, so called because of their similarity to the galvanized cans found around hospitals.

gabby (Br.N.), a soldier; called also Swaddy.

***gadgets,** I, flying-corps slang for inventions; II (Br.N.), "Anything, everything — parts of mechanism — and so on. Anything whatever, we call gadgets. We're gadgets too. Parts of the Naval Machine. That's what we all are. Just gadgets." — quoted by Vaux on title-page of *Gadgets*.

galley: "They are pleased and proud of their sea terms, and would not give them up for anything — not even if the soldiers of the King do not fathom their meaning. It is a case of going to the 'galley', while the red-coat that was persists in the 'kitchen'. The first field dressing station is nothing but 'Sick Bay' to the R.N.D. man. They 'go adrift' when they are missing from parade, and they ask to 'go ashore' when they want leave." — M. Hall, *Some Naval Yarns*, p. 40. This is a reference to a British Royal Naval Division which did all its fighting on land, and in which there were but few sailors.

galvanized derbies, helmets.

galvanized iron cans (Am.), big shells.

gas bombs (Am.N.), stale eggs. *See* Chow slang.

Gawdblimey hat, the soft, floppy type of service cap that some officers affected. *See* Blimey.

gens (Br.N.), leave.

German band, *see* Rhyming slang.

German up, a short way of saying that a German airplane was overhead.

Gertie-wears-velvet, a vernacularized form of the Flemish name, Godewaersvelde. This is said to be an almost perfect phonetic equivalent of the original.

get one's first, to be promoted from a second-class air-mechanic to a first-class air-mechanic.

get wind up, to become nervous or scared; to be flustered by danger. "Having myself been under fire on thirty or forty different occasions, I have found that 'getting the wind up' does not necessarily bear any relation to the actual danger. A man may on one occasion be undisturbed by a really serious situation, and yet at another time 'be windy' on very small provocation." — E. F. Wood, *The Note-Book of an Intelligence Officer*, p. 235.

getting a sub, touching an officer for a loan to be taken out of the next pay. "Sub" is obviously a clipped form of "subsidy".

getting the sparks: "Bullets from a machine gun cutting enemy barbed wire at night; when a bullet strikes wire, it generally throws off a bluish spark. Machine gunners use this method at night to 'set' their gun so that its fire will command the enemy's trench." — Empey, *Over the Top*, p. 293.

gill (soft g), look sharp; be quick; hasten.

gimper (Am.), one who would stick to you through thick and thin; a member of the "Gimper Squadron". "Gimper means a lot to us. It means more than scout, or pal, or comrade. I got the word from a mechanic I had when I was in the racing game. He was a gimper, and I knew when he finished with a motor, she would run. In this man's life there were two kinds of people — gimpers and bums." —

Lieut. Rickenbacker, *Lit. Dig.*, Aug. 24, 1918, p. 36.

Gimper Squadron (Am.), an American escadrille headed by Lieut. Rickenbacker.

***Gin Palace** (Br.N.), the *Agincourt*. This is a facetious popular etymology with *Palace* representing *-court*. "With vessels, the Lower-deck mint nicknames freely, from the *Agincourt* as the 'Gin Palace', the *Agamemnon* and *Lord Nelson* as the 'Aggie' and 'Nellie', *Bellerophon* 'Billy Ruffian', *Ariadne* 'Hairy Annie', and others down to the latest battleships, the prototype of which, the 'Dreadnought', the bluejacket promptly christened the 'Dread-O.'" — Vaux, pp. 57–58.

ginger, I, courage; "pep"; II, a red-headed soldier.

***gippo,** bacon grease; soup. This is said to be an Arabian word. *See also* Gyppo.

giving her the gun, advancing the gasoline control-lever of an airplane to turn on the gasoline.

go adrift, *see* Galley.

go ashore, *see* Galley.

go in off the deep end, to administer a reproof in angry terms.

go over the hill (Am.), to desert.

go west, to die. The explanation of this expression is obvious. The region of the dead is naturally in the land of the setting sun, and the dead have been "going west" from time immemorial. When Ulysses went to pay a visit to Hades, he directed his course westward. The mythologies of many tribes retain the same tradition today. See index to Tylor, *Primitive Culture*, s.v., *West*.

The following is Lewis Campbell's rendering of a passage in Sophocles' *Oedipus Tyrannus* (175–177):

"But flocking more and more
Toward the *western shore*
Soul after soul is known to
wing her flight,
Swifter than quenchless flame,
to the far realm of Night."

According to a folk-belief the corpse "should not meet the sun in its course, which is called burying the back-way". — Lean's *Collectanea*, Vol. II, Part II, p. 596. In antiquity some tribes buried their dead facing the setting sun.

The expression "to go west" was extended so that a soldier might speak of an airplane as having "gone west".

See *Notes and Queries*, Dec., 1918, p. 337.

goat (Am.), junior officer in a post, regiment, etc.

goaty (Am.), awkward; ignorant.

gob (Am.N.), a bluejacket. The sailors much prefer this word to "Jackie". A popular weekly states that there is evidence that this word originated on the Chinese coast. It was employed long before the war. A newspaper clipping says that the name originated at the time of Perry's expedition to Asia, when the Orientals called the American sailors "gobshites". It seems to be generally agreed that the name originated in Asia.

As is the case with many other words whose history is forgotten, explanations are not wanting. The following are given for what they are worth.

"Long before the Spanish-American War, out on the Asiatic Station, there was a long, lanky sailorman on the flagship by the name of Gobbles. Gobbles was a very well known character in the 'mosquito fleet,' as the Asiatic

Squadron was termed. Gobbles was a good-natured, easy-going sort of chap; he made a decided hit with the 'gang' because he could drink like a sea-gull and stand up longer than any man on the station. He could swill Tansan, Tsingtau or San Miguel and other beers of the Orient. He could put his shipmates away and go over to the Astor Bar, if he happened to be in Shanghai, and stick out the 48. He had the goats of every Limejuice sailor, marine or civilian ashore, because he could put 'em away every time in the beer battles.

"They first called this gentleman 'Shikepoke,' and he went by that handle for some time; since his name was Gobbles, they cut the two names in half and called him 'Gobshike,' so Gobbles changed his name to just plain, simple 'Gob,' and by that name he was known until he 'came home to the States.'

"The term 'Gob' later became so popular on the station that men coming home brought it back; later it was circulated in the North Atlantic Squadron, and still later throughout the service. To-day it is the sailorman's favorite, and he always refers to himself as a 'Gob.'" — Ruggles, pp. 10–11.

Among other less plausible explanations is the following: "In the olden days — back where ancient history started — there was a people, tribe or creed known as Gobbies. They were a ghost people and could only see at night; they lived in cliffs, high trees and deep under the ground. They were seldom seen out in daylight — in fact seldom seen at all. In later years the people were known as Gobbies, since they were of the spook variety or goblin, as they are sometimes called. And since all sailors were superstitious once upon a time, all suspicious characters were called Gobbies. And, too, sailors always abbreviate their words, and soon the term Gobbies was known as Gobs; in time, it is said that sailors began to refer to each other as 'Gobs.'" — Ruggles, p. 10.

God's rejected, men who act as guides for Tommies in London. "The persons who do this are men too old for service at home or abroad and are known, if I remember right, as the Volunteer Home Defense Corps. They wear a little band on their arm with the royal coat of arms and the letters "G.R." The person who evolved the design meant it for 'George Reigns', but the 'Tommies' went them one better and call these men 'God's rejected'. Not out of disrespect, but because they are 'Tommies'." — J. S. Smith, *Over There and Back*, p. 133.

going in, taking over trenches.

going out, being relieved from the trenches.

going over the wall, going to the detention prison. *See* Sieda.

going to stir, going to the detention prison. *See* Sieda.

going to the pictures: "That is Tommy's way of announcing that he is to go under the surgeon's knife, on a visit to the operating theatre." — Muir, p. 227.

gold brick (Am.), I, an unattractive girl; II, a shirker; one who tries to avoid work, or to get an easy job.

gold fish (Am.), salmon.

gooey, hash.

goopher (Am.), a slang term of the "Gimper Squadron". "When a new chap arrives, he's an egg. All good eggs soon become vul-

tures, and they are promoted to goopher standing." — Lieut. Rickenbacker, *Lit. Dig.*, Aug. 24, 1918, p. 36.

goose-step, a graceless and ridiculous German method of saluting with the feet.

got the crown, promoted to sergeant-major.

got the wrinkles out (Am. N.), said of a man who enlisted to get his hunger appeased and then scorns the "chow".

"Go-to-Hell" Whittlesey (Am.), Major Whittlesey, the commander of the so-called "Lost Battalion" in the Argonne Forest. *See* Lost Battalion. The expression "Go to Hell" is picturesquely described as the Major's answer to the German demand to surrender. He made no written reply to the demand. See *Everybody's*, April, 1919, p. 113.

gowed up (Am. N.), drunk. *See* Drunkenness.

grandmas, 15-inch howitzers, so called because they were short and stout.

Grandmother of the Russian Revolution, Madame Catherine Breshkovskaya, an agitator, who spent half her life in Russian prisons and in Siberia as an exile.

grandmothers, same as Grandmas.

***granny,** a term applied both to the 9.2-inch howitzer and the 15-inch gun.

grass-cutter: "This plane with clipped wings which keep it no more than six feet above the ground is variously nicknamed by the aviators 'grass-cutter', 'creeper', 'two-spot'. It is used to teach the ground-school graduates, whose experience in flying has been brief, by accustoming them to an almost instinctive control of the machine." — *The Independent*, July 6, 1918, p. 11.

grass-cutting, running a "grass-cutter" up and down the field.

gravel-agitators (Am.), infantrymen. *See* Names for infantry.

graveyard watch (Am. N.), the watch from midnight till 4 A.M., so called on account of the silence throughout the ship.

gray mule (Am.), corn whiskey; so called because of its color and its "kick". *See* White mule.

grease, butter; also "pull", "drag".

Green Guards, Czecho-Slovaks. *See* Guards.

Greens: "The 'Greens', otherwise known as the 'Green Guard', are groups of peasant soldiers who have deserted from the ranks of the 'Reds' and 'Whites' because they 'didn't want to fight any more'. When they cut loose, they made a bolt for the woods and the open country, where they remained in hiding, and hence received the nickname of 'Green Guards'." — *Lit. Dig.*, Jan. 10, 1920, p. 58.

grouse spots, trenches in the Vimy Ridge sector.

grouser, grumbler; growler.

Guards: Red Guards, Bolsheviki; White Guards, Bourgeoisie; Green Guards, Czecho-Slovaks; Black Guards, Anarchists.

***gubbins** (Br. N.), food which the sailor gets ashore. Naturally it means a kind not served aboard ship.

gumming the game, spoiling anything; meddling; interfering.

***gun-fire,** early morning tea. At one time a morning cannonade was the usual thing.

gunning, shelling.

gutser, the last straw.

gyp, vim; "pep".

Gypos, the Egyptian army; Egyptian laborers.

Gyppies, same as Gypos.

gyppo, gravy.

H

***hairbrush,** "a bomb used in the earlier stages of the war. It is shaped like a hairbrush and is thrown by the handle. Tommy used to throw them over to the Germans for their morning toilette". — Empey, *Over the Top*, p. 294.

hairies, I, goat-skin coats; II, draught horses, especially of the heavy artillery.

half-and-half trench, a trench built up with sand-bags to a height equalling the depth of the excavation, thus making the distance from the bottom of the trench to the top of the parapet twice the depth of the excavation.

half-loot, second lieutenant.

hanging on the slack (Br. N.), being indolent.

Hans, a German. *See* Names for Germans.

hard oil, butter.

hardheads (Am.), cavalrymen.

hard-lying money (Br. N.), the sixpence additional pay per day received by men on destroyers as compensation for the rigorous conditions of life aboard. The expression evidently has reference to the tossing and pitching of the boats. "A destroyer travelling at high speed in a heavy sea is like a bucking broncho." — H. R. Beston, *Full Speed Ahead*, opposite p. 114.

***hardtack** (Am.), hard bread, biscuits.

haricot beans, bullets.

Hash! Hash! Gas! gas! "It is said that on one occasion after soldiers had tired of hash which was being served for the n-teenth time, they hastily put on gas masks and spread the cry of 'Gas! gas!' For weeks after that the actual alarms were announced as 'Hash! hash!'" — *Lit. Dig.*, Feb. 8, 1919, p. 92.

***hate,** a battle or bombardment. This use of the word was suggested by the German "Hymn of Hate".

having a doss, having a sleep. *See* Doss.

having everything on a split yarn (Br. N.), ready to start at once.

He tried to step on one, said of a shell exploding under foot.

Heaven, Hell, or Hoboken by Christmas (Am.), a slogan of the American doughboys in parts of France during the summer of 1918. Hoboken was the port of embarkation.

heaving eggs, shelling.

heavy doughs (Am.), heavy artillerymen.

hedgehogs, egg-shaped criss-crossed tangles of wire.

Hell Terrors, a German designation for the Australians.

Hell-fighters (Am.), the 369th Infantry from New York City.

Hell's half-hour (Am.), a strenuous half-hour at bayonet practice. This expression was in common use at Camp Gordon, Ga.

hickboo, a rumpus; a bombardment. "Hickboo means a good many things, but chiefly that enemy aircraft are about. If Zeppelins or Taubes are on their way, a hickboo is on. Anything, in fact, which is calculated to put the wind up the timid is a hickboo. The word is said to be a distortion of an Indian word meaning an eagle." — *Lit. Dig.*, vol. 54, p. 1957. *See* Hickaboo, in Fraser and Gibbons.

hickie, a word applicable to anything whose name one does not remember; "what's-its-name".

hi-ex shells, high explosive shells.

high and dry (Br. N.), meat baked with potatoes round it. The dish has other names, for example, "Lundy Island" and "Schooner on the rocks."

high ball (Am.), salute.

higher ups, officers.

hike (Am.), a march; Tommy's "rout-march". "Perhaps 'hike' is our sole surviving linguistic legacy from our annexation of the Philippines." — B. Matthews, *Munsey's*, April, 1919, p. 418.

Hindenburg Line, the German defensive system in France, parts of which were named after various epic or mythic figures. The first five of the following names appear in Wagner's *The Ring of the Nibelungs*. The Alberich Line was named after a cunning sneaking villain who stole the Rhinegold; Wotan was the chief of the gods, a being symbolic of greed for wealth and power; Siegfried, the son of an incestuous union, came to a violent and untimely end; Hunding was a scoundrel; Brünnhilde, the wife of Siegfried, met her end by driving her steed into the flames of her husband's funeral pyre. Freia (Freya) was the Venus of German mythology. Parsifal was a personification of Christianity.

Newspaper despatches commonly used the word "Line" in connection with these names, although the Germans employed the word *Stellung*, "position".

hippo (a clipped form of *hippopotamus*), a type of airplane. *See* Names for airplanes.

his nibs, the commanding officer of an "outfit".

hissing Jennies, big shells.

Hit the deck, *see* Snap out of it.

hitch (Am.), enlistment. A soldier may speak of "three hitches in the navy and two in the army".

hitch in (Am. N.), a man who has enlisted for the second time.

hive (Am.), to discover; to catch.

Hobnail Express (Am.), the Empire (Twenty-seventh) Division. "This division was variously known in France, according to the members, as 'O'Ryans's Roughnecks', 'The Hobnail Express', and 'O'Ryan's Traveling Circus'." — *The New York Times*, Dec. 15, 1918, § 2, p. 3. General O'Ryan was the commander.

***hobo** (Am.), the provost-sergeant.

hog table (Am.), a table for the mess glutton. "The 'hog table' is plainly and bluntly so labeled upon a large cardboard sign that hangs directly above it. A day or so at the 'hog table' is apt to impress any recruit with the wisdom of moderation when the roast beef is passed." — R. F. Wilson, "Feeding the American Army," *The Century*, Nov., 1918, p. 79.

holy-brick (Am. N.), *see* Holy-stone.

holy-stone (Am. N.): "A stone about the size of a brick used to scour the decks of a warship. Sand is thrown upon the deck, soapy water is sprinkled around and then the holy-stone is pushed back and forth over the sand by the aid of a long stick and it cleans the deck and makes it snow white when dry. It is also called a holy-brick, or the rock of ages." — Ruggles, p. 74.

home farm, the married quarters.

homming and chevauxing, traveling in France in freight cars marked e.g., 40 HOMMES (men), 8 CHEVAUX (horses).

Hooverize, to save, a verb coined from the name of the United States Food Administrator, Herbert C. Hoover.

***hop over,** Australian for "go over the top".

horizontal exercise (Am. N.), lying down or sleeping.

hot and dirty, cocoa. This expression evidently originated from the

custom of taking cocoa when one was "hot and dirty".

hot-stuff (verb), to steal, "pinch", "lift", or appropriate to one's self.

hot-stuffed, stolen.

hot-stuffer, a thief.

***house,** I (Br. N.), the mess; II (Br.), a game much like lotto. The following description of the game is taken from Holmes, pp. 60–61: "The backers distribute cards having fifteen numbers, forming what they call a school. Then numbered cardboard squares are drawn from a bag, the numbers being called out. When a number comes out which appears on your card, you cover it with a bit of match. If you get all your numbers covered, you call out 'house', winning the pot. If there are ten people in at a franc a head, the banker holds out two francs, and the winner gets eight. It is really quite exciting, as you may get all but one number covered and be rooting for a certain number to come. Usually when you get as close as that and sweat over a number for ten minutes, somebody else gets his first. Corporal Wells described the game as one where the winner ''ollers 'ouse and the rest 'ollers 'ell!'

"Some of the nicknames for the different numbers remind one of the slang of the crap shooter. For instance, 'Kelly's eye' means one. 'Clickety click' is sixty-six. 'Top of the house' is ninety."

housewife, the soldier's sewing-kit.

how (Am.), a form of salutation in drinking, meaning, "Here's to your health", "My regards", etc.

how-guns, howitzers.

hugging the bath-mats, lying flat while the shells are flying overhead.

humming-birds, shells.

humpies, same as Elephant backs.

***Hun,** I, a German. In 1900 on the eve of the departure of the German troops to help quell the Boxer insurrection, the Kaiser urged them to play the part of Attila's Huns.

The Kaiser is reported to have said in part: "No mercy will be shown! No prisoners will be taken! As the Huns under Attila made a name for themselves, which is still mighty in traditions and legends today, may the name of Germany be so fixed in China by your deeds that no Chinaman shall ever again dare to look at a German askance." — *War Book of the University of Wisconsin*, p. 129. See also Smith, pp. 90–91.

II, a student airplane pilot. The title was due to the destruction they wrought in learning their duties. "A student who is learning to fly is called that on account of the queer things he does. Every pilot is a Hun until he has received his wings." — E. M. Roberts, *A Flying Fighter*, p. 336.

Hunding, *see* Hindenburg Line. *Hunding* is said to have been confused by the German soldiers with *Hundling*, "little dog".

Hun-getter, a term applied by the Royal Flying Corps to airplanes successful in beating German machines.

***Hungry Hundred** (Br. N.), a nickname applied to the first batch of supplementary lieutenants who entered the British Navy direct from the Merchant Marine.

Hungry Liz (or **Lizzie**), an ambulance stationed at a flying field ready for emergencies.

hush-hush boats, craft to serve as floating bases for airplanes. The name originated from the secrecy with which the new type of ship

was guarded. The purpose of the first boats of this type was to serve as cruisers to deal with raiders, but the guns were too powerful for the ships. See A. R. Bond, *Inventions of the Great War*, pp. 304–306.

***hush-hush ships,** floating aërodromes; same as Hush-hush boats.

hyphenate, a citizen of the United States who tries to maintain allegiance to the country from which he or his ancestors emigrated to the United States. The term was coined by Colonel Roosevelt. It was suggested by our habit of speaking of *German-Americans, Italian-Americans,* etc.

I

I.C. (Am.), inspected; condemned by an inspector.

I suppose, see Rhyming slang.

idlers (Am. N.), the men who did the work in the morning watch.

I'll chance my arm, equivalent to "I'll have a try", and probably implies that the "chancer" knows nothing about the job.

Illinois Division (Am.), the Thirty-third Division, composed of men from Illinois; called also "Prairie Division" and "Yellow Cross Division". Insignia, a yellow cross on a black circle.

Immelman turn, an acrobatic aërial "stunt" practised by the German ace, Immelman.

in dock, laid up with illness; in the hospital.

in the mill (Am.), in the guardhouse.

in the pink, an abridgment of "in the pink of condition".

Indian Head Division (Am.), the Second Division, Regulars. Insignia, a red Indian head on a white star.

Indian words, words which were brought home to England by the professional army or which are due to contact with the Indian soldier in France: Blighty, buckshee, cushy, doggo, jildi, pukka, pukka-wallah, wallah.

ink, wine. This use was restricted to red wine.

Iron Division (Am.), the Twenty-eighth Division, composed of Pennsylvania National Guard regiments; called also "Keystone Division" and "Pennsylvania Division". Insignia, a red keystone, an allusion to Pennsylvania as the "Keystone State".

Iron Jaw Division (Am.), the Thirty-second Division, so called because it was employed on both flanks of the Marne salient. *See* Broad Arrow Division.

***Iron ration:** "The 'iron ration' consists of a pound of 'bully beef', a small tin containing tea and sugar enough for two doses, some Oxo cubes, and a few biscuits made of reinforced concrete."—Holmes, p. 154.

It's a proper wash-out, it's a complete failure. *See* Wash-out.

It's good we have a navy, one of Tommy's expressions when he is disgusted with the Army and its work.

Ivy Division (Am.), the Fourth Division, Regulars. Insignia, four green ivy leaves on a drab-colored background. The choice of ivy leaves was due to a pun. When the Roman numerals IV are regarded as capital letters and are pronounced, we get *ivy*.

J

***Jack Johnsons,** large shells. This was a common designation of the German 17-inch shell, although it has been applied to missiles as small as those from the 6-inch

howitzer. This nickname had a great vogue at the beginning of the war before Jack Johnson had been dethroned from the heavyweight championship of the world. He was living in Paris at the time.

jackass rig (Am. N.), improper garb, as a pair of white pants with a blue jumper.

Jack-of-the-dust (Am. N.), "a man in charge of the commissary stores and storerooms; keeps the keys to the issuing room and serves out the rations for the day's consumption. He is generally a ship's cook, or a man who has had some experience in the galley." — Ruggles, p. 82.

jake, an army term expressive of satisfaction. If a girl is pretty, she is "jake". If anything is right, it is "jake". It has been suggested that the word is an Anglicized form of the French, *chic*, "becoming", "natty". The term is used in the American Navy also.

jam, any sort of good fortune. This use evidently originated at a time when there was a shortage of jam.

jammy, "lucky". *See* Jam.

jam-tins, trench-manufactured hand grenades used during the early part of the war. "The early grenades were crude affairs. They were made from beef- and jam-tins filled with explosive, shrapnel bullets, nails, odds and ends, and were ignited very generally by means of a cigarette and a fuse of uncertain duration.' It was a most primitive device and occasionally blew up the thrower, but this did not dampen the ardor of the sport." — *World's Work*, Sept., 1918, p. 501.

***jankers,** I, cells, prisons, "clinks"; II, offenders against minor points of discipline.

Java (Am. N.), coffee. *See* Chow slang.

jawbone, credit, a loan; to trust, to loan. This word was used nearly fifty years ago in the then territory of Washington in the sense of getting credit by talk.

"In those pioneering days in that section there was very little money in circulation. The men were busy most of the time in clearing land and building roads or trails. They raised most of their food, but were obliged to go to the store to buy clothing and other necessities they could not produce.

"The result was that most of these early settlers had to buy at the store on credit. Most of these bills in the community in which I lived, at least, were paid for with cedar shingles, which, as I remember it, was about the only commodity produced by the settlers that had anything like a cash value at the store. I remember that two or three of the neighbors who were notoriously lazy enjoyed a considerable credit at the store, and it was common talk in the neighborhood that they had obtained that credit by a good, strong line of talk, or 'jawbone'.

"When I was only 5 or 6 years of age, I was in the road with an older brother when one of our indolent neighbors drove along with a winter's supply of flour and some clothing in the wagon behind his ox team. My brother said to him: 'Did you get all that on jawbone?' He replied: 'Not exactly; I got half on jawbone and half on a load of shingles I promised to deliver next week, but mebbe the road'll be too bad to git 'em out of the wood." — A letter to *The New York Times*, March 3, 1918, § 2, p. 2.

jawhawker (Am. N.), a new country boy who is habitually star-gazing when he should be paying attention to duty.

Jayhawkers (Am.), the Eighty-ninth Division, composed of men from Kansas, Missouri and Colorado. The word was used of participants in the free soil conflict in Kansas in the early sixties. Insignia, a black monogram "MW" (Middle West). *See* Western Division.

jelly beans, girls.

***Jerry,** I, a steel shrapnel helmet; II, a German. *See* Names for Germans.

Jersey Lightnings (Am.), the Seventy-eighth Division, composed of New Jersey, Delaware and New York troops; called also "Lightning Division". Insignia, white forked lightning on red semi-circle.

jildi, hurry. This word is traceable to contact with the Indian soldier.

jingled, drunk. *See* Drunkenness.

jippo, fat.

Johnny Turk, a Turk, a designation much used at Gallipoli.

judies, girls.

juice-box (Br. N.), the gramophone.

juicey (Br. N.), the wireless operator or telegraphist. *See also* Angel.

jump (Am.), to admonish.

jump-cards, cards to measure the wobble of artillery projectiles. "These are cards placed at intervals extending in the line of fire and through each of which the projectile passes. The hole that it makes in each card tells whether the projectile is wabbling or not at that instant, and if so, in what direction. If it does not wabble, each hole will be perfectly round and the same diameter as the shell. If it wabbles, the hole will be oval with the long axis in the direction of 'yaw'." — *Everybody's,* July, 1919, p. 72.

jumping ship (Am. N.), leaving the ship without the proper authority.

jumping-off point, the point from which the attack begins. *Jumping-off place* is a phrase of frequent occurrence in journals of early Western travel to designate the starting point on the frontier.

K

K.O., the highest "kommanding" officer of an organization; "C.O." indicates the commander of a smaller unit.

K.P., *see* Kitchen police.

keep, a point of resistance, or an angle for attack.

Keystone Division (Am.), the Twenty-eighth Division, composed of Pennsylvania National Guard Regiments. *See* Iron Division.

kicked (Am. N.), dishonorably discharged.

Kings of No Man's Land: "The Second Brigade of the First Division have won for themselves the title of 'Kings of No Man's Land'. To them that dread country between the trenches is no longer known as No Man's Land. They call it 'The Dominion of Canada'." —A. H. Chute, *The Real Front,* p. 246.

***kip,** sleep, bed; to sleep. This is an old word in thieves' cant.

kissin' the gunner's daughter (Br. N.), the uncomfortable posture the seaman has to take across the breech of a gun to receive the cat-o'-nine-tails.

kissing the earth, a crash in which the airplane stands on its nose.

kitchen police (Am.), men detailed to help the cook in menial tasks. A soldier who was assigned to the "kitchen police" wrote home as follows: "Dear Mother: — I put in this entire day washing dishes,

sweeping floors, making beds, and peeling potatoes. When I get home from this camp, I'll make some girl a mighty fine wife." — *The Outlook*, May 15, 1918, p. 124. A popular song of war days and the soldiers' parody of it run thus:

"K-K-K-Katy, beautiful Katy,
You're the only g-g-g-girl that I adore.
When the m-moon shines over the cowshed,
I'll be waiting at the k-k-k-kitchen door.

"K-K-K-K.P., damnable K.P.
You're the only kind of work that I abhor.
When the m-moon shines over the guardhouse,
I'll be mopping up the k-k-k-kitchen floor."

Kitcheners (Br.), a name given by the Regulars to soldiers enlisting for the emergency.

***Kitchener's Mob,** England's first citizen army. "'Kitchener's Mob' they were called in the early days of August, 1914, when London hoardings were clamorous with the first call for volunteers. The seasoned regulars of the first British expeditionary force said it patronizingly, the great British public hopefully, the world at large doubtfully. 'Kitchener's Mob', when there was but a scant sixty thousand under arms with millions yet to come." — J. N. Hall, *Kitchener's Mob*, p. 1.

kites, weights used on the sweep-wire in mine-sweeping. "Sweeping mines . . . is not a particularly intricate process. It consists essentially in dragging a heavy wire between two vessels. In order to bury the wire to a sufficient depth beneath the surface to insure catching the mines, 'kites' are attached to the sweep-wire just astern of each vessel. These kites fly down in the water in much the same manner that an ordinary kite flies up in the air." — *Nat. Geog. Mag.*, Feb., 1920, p. 105. See also illustration of manner of operation, p. 108.

kitting-up, supplying with kits.

***kiwi,** an officer in the ground service of the flying corps. Kiwi is the Maori name for a New Zealand bird known to ornithology as Apteryx, "wingless". For a picture and description of the kiwi, see *The Encyclopaedia Britannica*, s.v., *kiwi*.

The following clipping shows how the history of a slang expression may become obscured: "The application of this term to the ground officer was the result of an evident belief on the part of the cadet who first used it that the kiwee (*sic*), a worthy member of the bird family, was a non-flyer. Bird lovers and naturalists who wrote to Texas newspapers in defense of the kiwee showed that quite the contrary was true. Nevertheless the name stuck." — *The New York Times Magazine*, March 30, 1919, p. 4. There is evidently some popular confusion here since none of the compiler's well-informed Texas friends has heard of a "kiwee" in Texas.

knock the end in, to spoil the whole thing. *Compare* Knock the end off, in Fraser and Gibbons.

knocked off, killed.

knuckle knife, a short dagger with a studded hilt. It was invented by the Germans.

L

lachie (Am. N.), milk. *See* Chow slang.

***Ladies from Hell,** a German name

for Scotch "Kilties". In *The Emma Gees*, McBride says the expression was first applied to the Canadian Highlanders at Langemarck, but afterward designated all Kilties.

Lafayette Division (Am.), the Eleventh Division, which was organized at Camp Meade, Maryland, in Aug., 1918. It became known as the Lafayette Division; the profile of the Revolutionary hero is represented in the insignia.

Lafayette, we are here, a sentence which General Pershing is reported to have uttered as he stood by the tomb of Lafayette in Paris. These words were spoken, not by Pershing, but by Colonel Stanton, a member of Pershing's staff.

land-cruiser, a name commonly applied to the tank in its experimental stage.

***land-ship,** same as Land-cruiser.

lathouse, latrine.

latrine sergeant, a private whose duty it was to keep the latrines in order, clean the floors, keep the fires going, etc.

Laura, a motor lorrie.

leaping-off trenches, trenches from which attacks were launched.

leather, meat.

***leathernecks** (Br. N. and Am.), Royal Marines. The name was suggested by the tight military collar. Called also Bullocks and Port Mahon Sodgers.

The designation is used also of the U.S. Marines, one of whose most boastful songs runs as follows:

"The Leathernecks, the Leathernecks, with dirt behind their ears!
The Leatherneck's the man that mops up all the beers;
The infantry, the cavalry, and the dirty engineers
Couldn't lick the Leathernecks in a hundred thousand years."

Leave Nothing Loose, Tommy's parody on Loyal North Lancs.

Lee Division (Am.), the Eightieth Division. *See* Blue Ridge Division.

The following account of the naming of this division is quoted from *The Army and Navy Journal* by *The New York Times*, Dec. 29, 1918, § 4, p. 8: "The 80th Division of the National Army, in real Winter quarters in the 'Sunny South' — the mercury hovering at a point between 4 and 6 degrees below zero — received its distinctive designation. The baptism occurred at Camp Lee, just outside Petersburg, Va., in connection with a memorable tribute by soldiers to a departed soldier, the leader of the lost cause. The occasion was the birthday anniversary of General Robert E. Lee.

"The baptism occurred as the climax of a brief but inspiring address by Brig. Gen. Lloyd M. Brett, commanding the 80th Division and the camp. After thanking the people of Virginia for their hospitable treatment of the soldiers of the command, General Brett concluded: 'When the great call comes for us to go "over there" and we have stood the acid test of battle, then — and not until then — bestow on us the name *Lee Division*.'

"Enthusiastic cheering followed General Brett's suggestion, and it was adopted unanimously, with this slight modification, the 80th Division will not have to wait until it has stood the acid test of battle; it was then and

there named *Lee Division*, and as such it will be known in history until the end of time."

leef, leave, pass, furlough.

lemons, lemon-shaped bombs or grenades. *See* Bombs.

liberty cabbage (Am.), the restaurant war name for sauerkraut.

Liberty Division (Am.), the Seventy-seventh Division, composed of New York drafted troops. Insignia, the New York Harbor Statue of Liberty represented on a blue field. This division is called also "Melting-pot Division", "Metropolitan Division", "Upton Division". "New York's Own" has been applied both to the Twenty-seventh and Seventy-seventh Divisions.

liberty steak (Am.), the quick-lunch waiter's war name for Hamburg steak.

lids, helmets.

light hands, a gentle touch in handling the "joystick".

Lightning Division (Am.), the Seventy-eighth Division. *See* Jersey Lightnings.

lima (Am.), another form of "limey".

limey (Am.), a British sailor or ship. This use of the word is due to the old "lime-juicers", on which lime juice was given to ward off scurvy.

Lincoln Division (Am.), the Eighty-fourth Division, composed of men from Illinois, Indiana and Kentucky. It was so christened while stationed at Camp Zachary Taylor, Kentucky.

Linseed Lancers, the Royal Army Medical Corps.

Little Archibald, a special gun to fire parachute flares.

Little Bertha's, German "105's".

Little Black Devils, the Winnipeg Rifles. Sometimes the designation was restricted to the Ninetieth Winnipeg Rifles.

Little Frenchman (Fr. Petit Français), the French "75".

Little Lena's, German "77's".

Little Mary, a type of shell.

Lloyd George's pets, munition workers in England.

Lone Star Division (Am.), the Thirty-sixth Division, composed of National Guard troops from Texas and Oklahoma. The name is due, of course, to the fact that Texas is the Lone Star State. Insignia, a white star on a red disc.

This designation replaced the name "Panther Division". "After consultation of representative officers of the National Guard of Texas and Oklahoma, it was decided that the appellation *Panther Division* was in no way appropriate, and that hereafter the Thirty-sixth Division shall be known as *The Lone Star Division*, and that its emblem shall consist of a five-pointed star with the numerical designation '36' superimposed in the center of the Star." — *The Statesman* (Austin, Texas), Oct. 19, 1918. It is said that the Division was renamed while in France.

The divisional insignia became, however, a blue Indian arrowhead with a khaki "T" superimposed upon it. The "T" represents Texas and the arrowhead Oklahoma, formerly Indian Territory.

lonely stab: "A girl who writes and sends parcels to Tommy. She got his name from the 'Lonely Soldier Column' of some newspaper." — Empey, *Over the Top*, p. 298.

long Blighty, assignment to prolonged duty in England.

***Longhorns**, *see* Mechanical cow.

looking spare, having nothing to do.

loose-wallah, a thief. *See* Wallah and Pukkawallah. *See also* Loos-Wallah, in Fraser and Gibbons.

lose one's can, to be killed. This referred most commonly to men shot through the head.

***lose the number of one's mess** (Br. N.), to die or to be killed.

Lost Battalion, The 1st Battalion, 308th Infantry (Seventy-seventh Division), commanded by Major Charles W. Whittlesey. Its communications were cut late in September and also early in October, 1918, while it was advancing into the Argonne Forest. Its position, however, was always known. Its story is told in *Collier's Weekly*, Nov. 16, 1918. See also *Everybody's Magazine*, April, 1919.

lota (Am. ambulance), anything incredible.

Lundy Island (Br. N.), meat baked with potatoes round it. *See* High and dry.

M

***Machonochie** (sometimes spelled Machonichie), "a scientifically compounded and well-balanced ration, so the authorities say. It looks, smells and tastes like rancid lard". — Holmes, p. 212. It is a concoction consisting of meat, potatoes, beans, tomatoes, parsnips, and various other things. It is named after the maker.

Mademoiselle Promenade, a French Miss who was willing to waive formality in order to accept Tommy's invitation to promenade.

maggots, fast little airplanes which guarded reconnaissance machines from overhead, underneath, and on the sides; called also "vipers".

making knots (Am. N.), said of anything that is moving fast.

***male tanks,** a type of tank armed principally with rapid-fire cannon; female tanks were designed for lighter work and were equipped with machine-guns.

Maps and Soundings (Br. N.), the navigating lieutenant.

marmalades: "New arrivals in camp were always called 'Marmalades', because they were distinguished by their relish for marmalade jam." — Knyvett, *"Over There" with the Australians*, p. 53.

Marne Division (Am.), a nickname of honor conferred on the Third Division by Major-General Joseph T. Dickman after its exploits on the Marne opposite Château-Thierry. "The three white stripes of its insignia are symbolical of the three major operations in which the division participated — the Marne, St. Mihiel, and the Meuse-Argonne. The blue symbolizes the loyalty of those who placed their lives on the altar of self-sacrifice in defense of the American ideals of liberty and democracy." — *Nat. Geog. Mag.*, Dec., 1919, p. 511.

Me no comprée, "I don't understand", an expression picked up by Tommy Atkins in France. "This is not the natives' pidgin English or Tommy's pidgin French, but a real sample of the atrocious French spoken by some of the peasants and villagers with whom our troops find themselves."

meat-ticket, wrist-tag for purposes of identification; "dog-tag".

mebus: "The emplacements in the Hindenburg line, as elsewhere, were variously used as machine-gun posts, observation-posts, trench-mortar positions, snipers' posts, etc. The British referred to this type of concrete pill-box as a 'mebus'." — Trounce, *Fighting the Boche under Ground*, p. 179. See Fraser and Gibbons s.v.

Mebu, the correct form in the singular number.

*mechanical cow, an airplane so nicknamed because of its clumsiness in the air. "Some machines of this type possessed an elevator situated out in front of the body and supported by two long outriggers. The machines with these long outriggers were called *Longhorns*, those without them *Shorthorns*." — V. Drake, *Above the Battle*, p. 31.

mechanical fleas, Ford automobiles.

Melting-pot Division (Am.), the Seventy-seventh Division, so named because composed of a sprinkling of all the nationalities that make up the cosmopolitan population of New York. It is said that hundreds of the men could not speak English when they were drafted. The Division acquitted itself in true American style. *See* Liberty Division.

mercy blow through, rhyming slang suggested by the French *merci beaucoup*, "many thanks".

mess gear (Am.), mess kit.

Metropolitan Division (Am.), the Seventy-seventh Division. *See* Liberty Division.

mick (Br. N.), an abridgement of "face like a scrubbed hammock".

middle heavies: "The 'middle heavies' with percussion fuses, which burst on impact and give out a dense black smoke, have been called 'Jack Johnsons' and 'coal boxes', but are now usually grouped under the general designation of 'crumps', because of the peculiar sound of their explosion. They run all the way from 4.1 inch to 9.2 inch calibers. Some of the very large shells are called 'Grandmothers' or 'railroad trains'." — McBride, *The Emma Gees*, p. 135.

Middle West Division, the Eighty-ninth Division, composed of men from Colorado, Kansas and Missouri. The insignia is a circle with a "W" in the center, which, when inverted, becomes the letter "M". The central open space has various colors to indicate different organizations.

*Mike and George, an award for bravery in the field. These two names playfully compare the award to the honor of "K.C. M.G." (Knight Commander of the Order of St. Michael and St. George).

mill (Am.), the guardhouse.

*mince pie, *see* Rhyming slang.

Mind your eye, judge (Am. ambulance), be careful.

Minnehaha, a German trench-mortar. The nickname is a sort of play on the German word *Minenwerfer*, "mine-thrower".

Minniewhuffer, a vernacularized form of *Minenwerfer*.

Missouri humming-birds, Missouri mules.

moaner, a pessimist.

*mob, a term used at Gallipoli for regiment.

Moffen: "'The Dutch language,' he (Raemaekers) continued, 'contains no derogatory nickname for any foreigners except the Germans, who are called "Moffen", and generally "die verdomde Moffen". This word is equivalent in meaning to the French "Boche". When a Dutchman wishes to insult a fellow-countryman, he speaks of him as a "Moff". Dutch seamen, for instance, who rather look down upon the Dutch farmers, sometimes refer to them as "Moffen". Whenever this is done within hearing of a farmer, a fight is sure to result.'" — Wood, *The Note-Book of an Intelligence Officer*, p. 116.

monkey drill (Am.), rough-riding in the cavalry.

monkey meat, canned beef and potato-hash.

monkey suits, fur suits for high flying.

moosh, the guardroom.

moppers-up, grenadiers whose duty it was to kill or subdue the defenders of enemy trenches already captured or passed over by the assaulting wave. *See* Mopping-up, in Fraser and Gibbons.

mosquito fleet (Am.), the fleet of small boats, pleasure launches and other craft pressed into service by the United States Government as submarine chasers.

mosquitoes, small mobile French tanks corresponding somewhat to the British "whippets".

***mother,** a howitzer not so large or heavy as "Grandmother"; in general, the 12-inch howitzer.

mother ship, a vessel to accompany and supply the needs of submarines or to act as a base for them.

mouse-trap (Am.), a plant at Willoughby, near Cleveland, built for the manufacture of Lewisite. It was so called by the workmen because every one who entered the eleven-acre stockade did so under an agreement not to leave until the end of the war. The purpose of this action was, of course, to guard the secret of manufacture.

"Lewisite is a gas so deadly that it has seventy-two times the killing power of the most deadly gas used in the war." — *Harper's,* Nov., 1919, p. 829.

movies, the searchlight. A man working a searchlight is said to be on the "pictures" or "movies".

mud-crunchers (Am.), the infantry. *See* Names for Infantry.

***mudlarks,** engineers.

muffler (Am. ambulance), gas-mask.

mule-skinner (Am.), a teamster.

Mulligan, a stew made of the regular ration issue and whatever extras may come to hand.

Mulligan battery, the cook wagon.

mungey, food in general.

munition mongering, profiteering.

***mustard gas,** a gas that smells like mustard and makes the eyes water. "Recently a new 'mustard gas' has been used by the enemy with deadly effect, owing to the fact that it is both invisible and odorless. It is sent over in exploding shells, and sinks in a heavy invisible vapor about the sleeping men, creeping into their dugouts and trenches or enveloping them around the guns or in the shell holes. The effects do not manifest themselves for several hours. With stinging pain the man's eyes begin to close, and for a time he may go almost blind. He is then taken violently sick. The surface of the lungs and the entire body, especially where it is moist with perspiration, is burned. The skin may blister and come off. Many cases have proved fatal and many more suffer cruelly for weeks in hospital." — S. Eddy, *With our Soldiers in France,* pp. 46–47.

***mystery ships,** vessels which can be quickly converted from seeming tramps into gun-decked ships of war. They were designed for use against the submarine. They were so named, of course, from the veil of secrecy which was thrown about them. The designation has been applied to submarine monitors also. *See* Panic party.

For pictures and description of the methods of operating these ships, see Sims, "Decoying Submarines to Destruction," *World's Work,* Jan., 1920, pp. 248-272.

N

N.C.O. (Am.), an abbreviation meaning "non-commissioned officer", but humorously interpreted as signifying "non-combatant officer". It was applied to non-combatant officers in Washington.

names for airplanes, Camel, Dolphin, Hippo, Pup. These were machines of the Sopwith make which bore some resemblance to the creatures after which they were named.

names for Germans, Fritz, Hans, Heinie, Jerry, Hun.

names for infantry (Am.), Doughboys, Dust-disturbers, Gravel-agitators, Mud-crunchers.

names for tanks, Leviathan, Mary Ann, Vampire. These are individual names for tanks, not class names.

***napper,** head. "The caution to keep your head down always came, 'Keep your napper down low'." — J. Gallishaw, *Trenching at Gallipoli*, p. 136. Napper is an old English word found in a number of dialects.

Nash-fish, A British type of hydrophone.

native sons, prunes.

nest, I, a dugout; II, a machine-gun position or emplacement; III, the concealment of a sniper.

New England Division (Am.), the Twenty-sixth Division. *See* Yankee Division.

New York Division (Am.), the Twenty-seventh Division, composed of National Guardsmen from New York. *See* Empire Division.

New York's Own (Am.), a title that was given to the Seventy-seventh Division as well as to the Twenty-seventh.

nibbling, the term applied by General Joffre to his policy of regaining France piece by piece.

night ops, night operations or maneuvers.

night rolling, driving an ambulance at night.

no bon, no good. *Bon* is French for "good".

No bonne, same as *No bon*. *Bonne* is the feminine form of *bon*.

***No Man's Land,** the space between the hostile trenches.

The designation is interesting whatever its origin. The Oxford Dictionary says, s.v. No man's land: "A piece of waste or unowned land; in early use as the name of a plot of ground, lying outside the north wall of London, and used as a place of execution."

In discussing ploughing F. Seebohn, *The English Village Community* (1890 ed.), p. 6, writes: "In other cases little odds and ends of unused land remained, which from time immemorial were called 'no man's land,' or 'any one's land,' or 'Jack's land,' as the case might be."

Mark Twain, *Following the Equator* (Harper's), p. 225, has some comments on the expression: "Australia has a slang of its own. This is a matter of course. The vast cattle and sheep industries, the strange aspects of the country, and the strange native animals, brute and human, are matters which would naturally breed a local slang. . . . The wide, sterile, unpeopled deserts have created phrases like 'No Man's Land' and the 'Never-never Country.'"

The United States once had a piece of land called No Man's Land between the 100th and 103d meridians of longitude and the parallels of latitude at 36 degrees 30 minutes and 37 degrees. See *The* [Chicago] *Daily News Alma-*

nac and Political Register for 1889, p. 184. The name has in fact been applied to outlying districts in various countries. See *The Encyclopedia Americana* (1919), Vol. 20, p. 381.

not 'alf: "To do anything 'not 'alf' — in the cockney lingo — was to do it with a genuine and superlative excellence." — *The New York Times*, March 2, 1919, § 4, p. 1.

nothing to write home about: "Miserable conditions in the desert or in the trenches, bad accommodation, doubtful food — anything which cannot arouse the faintest enthusiasm of any sort — these, in the lingo of the much-travelled and stoical troops, are 'nothing to write home about'." — Muir, p. 227.

number nine, a cathartic pill; a cure for all ills.

number one rig (Br. N.), the best clothes a bluejacket has.

O

O.D., I, the officer of the day; II, olive drab.

O.D. pill (Am.), a pill olive drab in color, taken as a physic.

O.F.'s, offensive hand grenades.

O Pip, an observation post (signaler's alphabet). *P* was pronounced *Pip* to insure understanding.

***office (The),** the pilot's cockpit. "*Wouf!* — a deafening crash and the old bus shakes violently as I put my head into the office." — *Blackwood's Magazine*, Oct., 1918, p. 526.

***oil can,** "a German trench mortar shell, which is an old tin filled with explosive and junk that the Boches have no further use for". — Empey, *Over the Top*, p. 302.

oil slick (Am.): "The submarine when running close beneath the surface leaves what is known as an 'oil slick'. That is, the oil that is discharged in the exhausts floats on the top of the water in tell-tale streaks, and where there is an oil slick there also is likely to be a destroyer.

"'Oil Slick' is American terminology. The British Admiralty did not approve of the use of the term at first, but nobody in the Admiralty could present a better descriptive phrase, so now it is officially recognized, but with due British reservation." — *Sat. Eve. Post*, Oct. 12, 1918, pp. 89–90.

Old Blue Lights (Br. N.), the gunner.

***Old Contemptibles:** At the beginning of the war, the Kaiser spoke slurringly of England's "contemptible little army". The soldiers took the cue and called themselves the "Old Contemptibles".

old family cuckoos, a nickname for a certain type of rolling machine on which aspiring aviators were trained.

Old "Fighting 69th" (Am.), the 165th Infantry of New York.

old file (Am.), an old officer.

Old Hickory Division (Am.), the Thirtieth Division. "The division is constituted of National Guard troops of North Carolina, South Carolina, and Tennessee, augmented by many thousands of selective draft troops from the states of Indiana, Illinois, Iowa, Minnesota, North Dakota, North Carolina, South Carolina and Tennessee. The Division was dubbed 'Old Hickory' after the warrior and statesman Andrew Jackson, who was so closely identified with the history of the states furnishing the major portion of the personnel," — Col,

J. K. Herr, *The New York Times*, March 2, 1919, § 4, p. 1.

This division has been frequently called the "Wild Cat Division," because its men came largely from the same states that supplied the Eighty-first ("Wild Cat") Division.

Insignia, monogram of blue, with the letter "O" surrounding the letter "H", with three X's (Roman numerals for 30) forming the crossbar of the letter "H".

old issue (Am.), an old soldier.

Old man Joss, the patron saint of all submarine men.

olive oil, a soldier's representation of *au revoir*.

on official terms (Am.), not on speaking terms except officially.

on the cot, refraining from drink; "on the water-wagon".

***on the pegs,** under arrest.

on the tack, refraining from drink; "on the water-wagon"; same as On the cot.

on the wire, said of a man who was wanted and could not be found.

on your own, freedom or permission to do as you please. "An officer generally puts Tommy 'on his own' when he gets Tommy into a dangerous position and sees no way to extricate him." — Empey, *Over the Top*, p. 302.

One Bumstoff, Von Bernstorff. *See* Von Woodenburg.

One O'clock, a Canadian name for Von Kluck.

***one-up,** a lance corporal who wore one stripe.

one-winger, an observer who wore a one-wing badge on his uniform.

***onion,** a flaming explosive shell or rocket used by the Huns against airplanes. *See* Flaming onions.

***oojah,** anything; similar to Oojiboo.

***oojiboo,** "gadget"; "thingummy"; "what-d'ye-call-it".

openers (Am.), cathartic pills.

orderly bucker (Am.), a soldier, who, when going on guard, strove by extra neatness of appearance to be designated as orderly for the commanding officer.

orderly room (Am.), the company office.

orphans (Am.), a term applied by American doughboys billeted in small French towns to their unfortunate companions who failed to get attractive Mademoiselles to give them "French lessons".

O'Ryan's Roughnecks (Am.), *see* Hobnail Express.

O'Ryan's Traveling Circus (Am.), *see* Hobnail Express.

Out pipes, *see* Sick Bay Express.

***out there** (Br.), England's equivalent for "Over there".

outfit (Am.), a regiment, or, in fact, almost any army unit.

outlaw (Am.), an unruly horse.

over the lump (Am.), beyond the half-way period of enlistment.

over the top, jumping out of the trenches to make an attack. On one occasion Negro stevedores at a base port in France were discussing the meaning of this expression. One of them explained it as follows: "Well, de 'top' is a place where you goes over, and when you goes, you says, 'Good mawnin', Jesus'. Dat's all."

over there (Am.), in France.

owner (Br. N.), the commanding officer of a vessel.

Ox and Bucks (Br.), Oxford and Buckinghamshire Regiments.

P

***P.B.I.:** "Poor Bloody Infantry, a phrase applied by the weary 'foot-slogger' to himself, seeing that he gets a greater share of the kicks than, and the fewest halfpence of, any arm of the service."

— *Notes and Queries*, Dec., 1918, p. 333.

pacifist, one opposed to the arbitrament of arms as a means of settling international disputes. This is an emergency war word and does not appear in the dictionaries printed before the war.

"Theoretically, there is no question but that we should say 'pacificist' and 'pacificism', just as we say 'publicist' and 'Catholicism'. But a false sense of analogy has made itself felt in this case. People think of economic, economist; lyric, lyrist; philanthropic, philanthropist; and so they say pacific, pacifist. The analogy is false because 'pacific', as mentioned above, is formed with the suffix *–fic* and not with the suffix *–ic*, which usually represents the Greek *–ikós*. It is common, though not invariable, in the case of these words derived from the Greek, for the *–ic* to be dropped before the *–ist* or *–ism* is added. So that, although we are quite justified in saying 'heroism' instead of 'heroicism', we ought not to say 'pacifism', but 'pacificism'. There is no sense in cutting off the *–ic* of *fic* and leaving the lone *f* remaining. Added to the false sense of analogy is a phonetic reason of some weight. 'Pacifism' is shorter and easier to say than 'pacificism', and the contraction avoids one of a rather disagreeable series of sibilants." — A. H. Weston, *The Nation*, Vol. 105, p. 174.

***Paddy Doyle**, same as Jankers.

***Padre** (Br. N.), the chaplain; "Sky Pilot"; "Holy Joe".

***pancake**, to slow down an airplane, dropping laterally and keeping the machine parallel to the ground; to land flat like a pancake.

pang (Br. N.), bread. This is the sailors' phonetic representation of the French *pain*, "bread".

***panic party**, a feigned demonstration of alarm or panic on board a decoy (mystery) ship in order to lure the commander of a submarine alongside. When a mystery ship was torpedoed, the panic party took to the boats, apparently abandoning the vessel, but always leaving on board another crew to man the guns and finish the submarine if it came near enough.

Panther Division (Am.), the name of the Thirty-sixth Division, composed of men from Texas and Oklahoma, while it was training at Camp Bowie, Texas. *See* Lone Star Division. "The 36th Division had as its insignia the picture of a fighting panther and below it were three Latin words that translated into English meant: 'We'll do it in spite of Hell'. Of course it was christened the 'Panther Division'." — *The New York Times*, Dec. 29, 1918, § 4, p. 8. This appellation was discarded while the Division was in France.

The new divisional insignia was the letter "T" (= Texas), superimposed on an Indian arrowhead to represent Oklahoma, which used to be Indian Territory.

pants rabbits, lice, "cooties", "chats".

parasol, a type of airplane. The Morane "parasol" is illustrated in Hall, *High Adventure*, p. 126.

Parsifal, *see* Hindenburg Line.

part brass rags (Br. N.), to sever a friendship. "In every ship a certain time of the forenoon is occupied in cleaning brass and woodwork, and, as there is work usually for two on one brass or other, friends generally share the work between them, and give

each other the free use of their polishing paste, emery paper, and rags. They share the same bag for these 'cleaning tricks', and, consequently, when the intimacy is broken up, and the 'tricks' separated, they 'part brass rags'." — Vaux, p. 59.

passed (Am. ambulance), died.

Pathfinder Division, the Eighth Division, which was organized at Camp Fremont in California in December, 1917. Insignia, a gold arrow pointing upward, running through a white figure "8".

peace-time trenches, trenches in a quiet sector.

Peanought, a special British name for one of the German big guns. *See* Polly.

***pelican** (Am. N.), the ship's 'hog'.

***penguin,** a low-power training airplane with small wings. "First of all the student is put on what is called a roller. It is a low-powered machine with very small wings. It is strongly built to stand the rough wear it gets, and no matter how much one might try, it could not leave the ground. The apparatus is jokingly and universally known as a Penguin, both because of its humorous resemblance to the quaint arctic (*sic*) birds and its inability in common with them to do any flying." — J. R. McConnell, *Flying for France*, p. 143.

penguins, members of the Women's Royal Air Force.

Pennsylvania Division (Am.), the Twenty-eighth Division. *See* Iron Division.

Percy, "a certain German long-range naval gun, whose shells have the peculiarity of bursting before you hear them arrive". — G. V. Williams, *With Our Army in Flanders*, p. 228.

perm (Am. ambulance), furlough. The word is obviously borrowed from the French *perme*, "furlough", poilu slang from *permission*, "leave".

***persuader,** I, a short club with a nail-studded head to induce prisoners to follow; II, the bayonet.

pheasant (Br. N.), a joint of meat baked by itself.

physical torture, physical training; "physical jerks".

picture show, big battle.

pictures, *see* Movies.

pie wagon (Am. N.), the ship's prison. It was ironically so called since no pie was served to one so confined.

pieso (Br. N.), close-fisted.

pile-up, a crash; a smash.

pill rollers, the hospital corps.

***pill-boxes,** concrete structures or blockhouses developed by the Germans for use in their "elastic" defense. They were employed as machine-gun nests.

pillows, balloons roughly shaped like rectangular wings and used as targets by airmen.

pills (Am.), the surgeon.

Pilseners, shells weighing 2800 pounds, from the Austrian Skoda howitzers.

pincer drive, an enveloping drive launched from two sides of an objective.

***pineapples,** I, bombs so called because of their shape and the criss-cross pattern of lines marking off the segments into which they burst; II, German aërial torpedoes, so called from their shape; III, light trench-mortars.

pinked, struck by bullets.

pinto (Mexican border slang), horse. The pinto is a Mexican pony with numerous white spots.

pipe down (Br. N.), cease talking; "clew up"; "shut up".

***pipped,** wounded or killed. "A sentry warns us 'In that bit of trench, sir, you must bend over as you go. It is enfiladed by an enemy sniper. He "pipped" one of our fellows through the head there yesterday.'" — Wood, *The Note-Book of an Intelligence Officer*, p. 182.

pips, the upraised portions of the insignia on the shoulder-straps of the uniform of the British officer.

***pip-squeak,** I, an onomatopoetic name for a shell. "The 'pip-squeak' is a shell that starts with a silly 'pip', goes on with a sillier 'squeeeeee', and goes off with a man's-size bang." — Holmes, p. 89; II, a temporary second lieutenant.

pistol lights, rockets shot from a pistol.

Pistol Pete (Am.), *see* Ricochet officer.

Plymouth Division, the Twelfth Division, so called because it was recruited mainly from the New England States.

pocked, pitted with shell holes. Land frequently shelled bore some resemblance to the face of a person who has had small-pox.

poggy bait (Am. N.), the sailor's designation for sweets.

***poilu:** When the French went to war in 1914, the care bestowed upon the face and the style of wearing or trimming beards and moustaches provided some index of the soldiers' social, industrial or professional status. A few barberless months in the trenches, however, eradicated all obvious distinctions of class or position, and the infantrymen became known as *poilus*, "hairy" or "shaggy". During the war the connotations of hardy, virile, brave, became very definitely attached to the word "poilu", although it was used in such senses long before the war. The etymology of the word seemed finally to fall into the background so that occasionally one saw the adjectives "hairy" and "bewhiskered" applied to poilu.

Among peoples of Latin extraction, the idea of virility or manliness is very commonly associated with the growth of hair upon the face. See Aristotle, *De Generatione Animalium*, 2.7.746b, and *Historia Animalium*, 3.11.518b. Cicero reproached some of the Catilinarian conspirators with being *imberbes*, "beardless".

"Un jeune homme qui n'a pas encore de poil au menton est considéré comme un être faible et dont l'opinion ne saurait être prise en considération."—Franc-Nohain et Paul Delay, *L'Armée française sur le front, 1914–1915*, p. 5.

policeman's truncheon, a bomb so called because it resembled a policeman's club. *See* Bombs.

politician (Am. N.), any man having a "soft" job, such as compartment cleaner, storeroom keeper, jack - of - the - dust, evaporator watch, ice-machine watch, yeoman or signal boy. These are known as political jobs. See Ruggles, p. 111.

Polly, a British name for one of their big guns. "My next shot at the Boche was with 'Polly', whose shell spat forth at her opposite number, known on our side of the lines as 'Peanought'." — M. Hall, *Some Naval Yarns*, p. 106.

pom-pom, a small anti-aircraft gun.

***poodle-fakers,** newly commissioned officers with an exaggerated sense of their own importance. "He (a big Australian private) encountered a pink-faced English youth, who had just got his

commission, one of the Percival or Cuthbert type, whom we refer to in the army as 'poodle-fakers'. The young one, with a due sense of his dignity, held up the big Australian private for not saluting him. 'Don't you know an officer when you see 'im?' he exclaimed. The Anzac drew himself up to his full height and, bending, clapped the youth with a mighty hand, announcing, 'Sonny, you trot along home and tell your mother that you've seen a real, live soldier'." — A. H. Chute, *The Real Front*, pp. 240–241.

poppin' off (Am. N.), "shooting off".

porridge pots, shells.

Port Mahon Sodgers (Br. N.), Royal Marines. This expression dates from the last days of the Eighteenth Century, when the Marines garrisoned Port Mahon in the Island of Minorca.

possie, jam. This seems to be a variant of pozzi (or pozzy). *See* Possy, in Fraser and Gibbons.

pot holes, shell holes.

poultice wallahs, the Royal Army Medical Corps. A popular etymology has distorted this into "Poultice swallowers". *See* Wallah.

pounding one's ear (Am. N.), sleeping.

power-eggs, the ovate objects at the sides of Zeppelins housing the engines. For a picture of them see *The Illustrated London News*, Nov. 17, 1917, p. 532.

pozzi, jam.

pozzy, jam.

Prairie Division (Am.), the Thirty-third Division, N.G., composed of men from Illinois. *See* Illinois Division.

praying tackle, religious robes.

Princess Pats, a Canadian regiment composed largely of South African veterans and reservists, which carried the colors worked personally by the Princess Patricia, daughter of the Duke of Connaught.

prison, names for (Am. N.), cage, jug, brig, cooler.

profiteer, a new word formed on the analogy of "commandeer", and meaning, "to take advantage of war-time conditions for purposes of gain".

proper names vernacularized: Wipers from Ypres; Arm in Tears from Armentières; Ballyall from Balleul; Hazy-Brook from Hazebrouck; Rude Boys from Rue de Bois; Eatables from Étaples.

props, a clipped form of "propellers".

prune picker (Am. N.), a Californian.

Prussian code of politeness: "'The Prussian code of politeness', we call it when they retire with two or three machines against one of ours." — M. Hall, *Some Naval Yarns*, p. 8.

pukkawallah: "*Pukka* means ripe, finished, in contradistinction to *kachha*, unripe, unfinished, so 'pukkawallah' for a dandy would imply correctness in get-up. 'Loosewallah', half English, half Hindustani, would imply that the thief was a 'bad 'un'." — *Notes and Queries*, Dec., 1918, p. 333. *See* Wallah.

pump handle (Am.), salute. This use has reference to the stiff snappy character of the salute.

punish, to shell. In this sense the word is evidently a translation of the much-used German word *strafen*.

***punk,** bread. This word was used in New York "bread lines" before the war.

***pup,** a type of airplane. The pup is described as being "of minute dimensions, playful temperament

and powerful disposition". *See* Names for airplanes.

***pup tent** (Am.), a small shelter tent. "Each man in the United States Army and in the National Guard carries half a shelter tent for use in the field. Half a tent consists of a sheet of canvas about five by eight feet, a jointed tent pole, five metal tent pegs, and a length of cotton line. When a halt is reached, each pair of men set up their tent poles, stretch the line as a ridge, tie their canvas sheets together, and peg them down as a cover. The result is familiarly called a 'pup' tent." — *Collier's*, April 21, 1917, p. 13.

***push** (hospital slang), a girl.

push and pull (Am.), sighting and aiming drill.

***pusher, I** (hospital slang), a girl (*See* Tractor); II, a biplane without front elevators.

pushing up the daisies, said of a soldier who had been killed and lay buried in France. *See* Pushing daisies, in Fraser and Gibbons.

Put a jerk in it, smarten your actions; put some "pep" in it.

put dots on one, to bore or tire.

put in a bag, killed.

put the wind up, to make afraid; to cause fright.

put upon the beach (Br. N.), said of an admiral or captain dismissed from his command.

put your skates on, to evade duty; to get clear.

putts (Am.), puttees.

PX, post exchange.

Q

Q-boats, decoy vessels used to lure submarines to destruction. They were equipped with disappearing mountings for guns concealed beneath hatchway covers and masked by deckhouses which collapsed like cards at the jerk of a lever. *See* Mystery ships and Panic party. *See* Q ships, in Fraser and Gibbons.

Q-craft, same as *Q-boats.*

***quiff** (Br. N.), money.

***quirk,** aviators' slang for pupil.

R

rabbit holes, listening galleries.

radish: "A 'Radish', Bolshevistically speaking, is . . . a man who fervently professes devotion to the Communist cause while harboring a secret longing for its overthrow. In other words, he is 'red' on the outside, but 'white' within, and that makes him a radish." — *Lit. Dig.* Jan. 10, 1920, p. 58.

Raf, a word formed from R.A.F., i.e., the Royal Aircraft Factory.

Ragtime Army, the Australasian forces.

railroad trains, a name applied to some of the very large shells.

Rainbow Division (Am.), the Forty-second Division, composed of men from 26 states and the District of Columbia. Insignia, a red, yellow and blue rainbow. The names of the states are as follows: Alabama, California, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Wisconsin.

See R. S. Tompkins, *The Story of the Rainbow Division*, p. 14.

ral (Br. N.), the commanding officer of a ship.

rammed in the mush, put in the guardroom. *See* Sieda.

ranked out (Am.), compelled to

vacate by a senior, e.g., "to be ranked out of quarters".

rat tail (Am.), mule.

rathskeller, a dugout.

***rations,** bombs for an airplane.

rattles (Br. N.), the cells.

rattlesnakes (Am.), the 369th colored regiment of New York.

raw tea, tea without sugar or milk.

real fug, *see* Fug.

Red Diamond Division (Am.), the Fifth Division. "Two derivations of this unit's nickname are given. The first is as follows: 'Diamond Dye — it never runs.' The second derivation is quoted from a staff officer and states, 'The Red Diamond represents a well-known problem in bridge-building — it is made up of two adjacent isosceles triangles, which make for the greatest strength'." — *Lit. Dig.* May 31, 1919, p. 90. *See* Ace of Diamonds Division.

red eye, catsup.

Red Guards, Bolsheviki. *See* Guards.

***red tab,** a British staff-officer, so called from the bright red tabs worn on either side of the collar to indicate rank.

red tape (Am.), official formality; the close or excessive observance of forms and routine in the transaction of business.

Red Watch: "The 48th Highlanders of Canada wore a sombre tartan like the 'Black Watch' (*see* Black Watch), interwoven with a broad red check, and it was whilst doing duty as patrol over a steel plant at Sault Ste. Marie that some striking Scotchmen first called the Canadian Regiment the 'Red Watch'." — J. A. Currie, "*The Red Watch*", p. 18.

Reds, revolutionists in Russia and Germany.

reeve one's arm through the ringbolt (Br. N.), to take one's ease.

regimental monkey (Am.), the drum major.

regular feller (Am.), a sailors' term for a mate who is a "good sport".

repeaters (Am. N.), sausages. *See* Chow slang.

***rest-camp,** the cemetery. "The German snipers were very active, now and then killing or wounding one of us. At one time a trench-mortar shell hit so close to my hole in the ground, that I was completely buried and for a moment or two I thought I was going to a rest-camp." — *Lit. Dig.,* March 29, 1919, p. 44.

re-up (Am.), to re-enlist.

rhyming slang: "Rhyming slang is extraordinarily common in the army, so common that it is used with complete unconsciousness as being correct and conversational English. . . . A man's arm is his 'false alarm'; his nose, 'I suppose'; his eye, 'mince pie'; his hand, 'German band'; his boot, 'daisy root'; his face, 'chevvy chase' [i.e. Chevy Chase]; and so forth — an interminable list." — Muir, p. 225.

ricco, a ricochet bullet.

ricochet officer (Am.), an officer used for emergency jobs. The following paragraph appeared in the St. Louis *Post-Dispatch,* Nov. 24, 1918: "Camp Kearney, Cal. — Two new bits of army slang have come into use here. The latest one is 'ricochet officer'. A 'ricochet officer' has nothing to do with the artillery range, it was explained, neither does he attempt to restrain glancing rifle bullets on the small arms target ranges. He merely 'ricochets' from one job to another within the camp, 'pinch-hitting' wherever the need for officers may exceed the supply, or serving in such temporary organizations as the casual com-

pany or recruit-receiving battalion. The other term is 'Pistol Pete', and it is applied to any 'hard-boiled guy' who is unapproachable, belligerent, a martinet or unduly strict with his men."

Rig in your booms (Am. N.), put down your elbows; an expression used at mess.

Rig in your stun sails (Br. N.), put down your elbows.

riveter, machine gun.

rock of ages (Am. N.), *see* Holystone.

roller (Fr. *rouleur*), an aviators' training machine which ran along the ground just about ready to fly, but which could not quite rise. *See* Penguin.

***rooky,** a raw recruit. "You can't drill, you can't walk, you can't shoot, . . . you awful rookies." — Kipling, *Many Inventions.*

Rotten Irish Ragtimers, Tommy's parody upon *Royal Irish Rifles.*

rout-march, a name applied by Tommy Atkins to a route-march. Officers in the old army often adopted the mispronunciation — quite as a matter of course. *Compare* Death-charge for Depth-charge.

rubber-heels, shells which give no warning of their approach; "Silent Sues".

rudder-tapper, a cross-wind encountered by an airplane in flight.

ruddy, similar to "bloody", but not so bad.

Rude Boys (or **Roodiboys**), an Atkinism for *Rue de Bois.*

***rumble,** to disturb; to annoy; to discover or detect in any trickery.

***rum-jar,** the trench-mortar, or its missile.

rumpty, "a machine of the Morris Farman type used in instructional work, called that on account of its queer movements in the air. It is sometimes called a longhorn on account of the long skids on the landing-gear and is a sister type to the shorthorn, which is minus this length of skids, and flies much faster." — E. M. Roberts, *A Fighting Flyer,* p. 338.

S

S.O.L., I, delete; a word applied to anything that can't be done, or is called off; II (Am.), *S*trictly *O*ut of *L*uck; III, *S*oldier *O*ut of *L*uck.

sag paste, a paste to protect the body from burns by gas. "Sag" is "gas" spelled backwards.

salve, butter; "axle-grease".

***Sammy** (Am.), an infantryman; a "doughboy". The name is evidently due to an effort to find a cousin for Tommy, and was suggested by the nickname Uncle Sam. The appellation was utterly lacking in spontaneity and it is not strange that the United States troops strongly objected to it. In *The Stars and Stripes,* March 29, 1918, p. 4, an editorial is headed "Down with 'Sammie'."

. A Canadian paper gives the following apocryphal account of the origin of the name: "The welcoming French shouted enthusiastically 'Vive les amis', pronounced 'Veev lay zammie', and the soldiers thought that instead of cheering their arriving friends, the crowds were giving them a nickname referring to Uncle Sam."

***San Fairy Ann,** that's all right. This is Tommy's version of *Cela ne fait rien,* "That doesn't make any difference". *Compare* Sandbag Mary Ann.

sand (Am. N.), sugar. *See* Chow slang.

sand and specks, salt and pepper.

Sandbag Mary Ann: "Mary Ann started her career as Fairy Ann

in the well-known phrase, *Cela ne Fairy Ann*, which is army French for *Cela ne fait rien*, one of the half-dozen items necessary for conversing with the remaining natives. *Fairy Ann*, not being sufficiently homelike for old soldiers, becomes *Mary Ann;* while — owing either to cherished idols at home being protected by sandbags or to the ignorance of the '18-pounders' (as the underage recruits are affectionately called) when Sammy apologizes to Tommy for pushing past him in the trenches — the cryptic phrase, "Sandbag Mary Ann", is more readily uttered and understood than the conventional 'That's all right, chum'." — *Notes and Queries*, Oct., 1918, p. 270.

sand-rat (Am.), a soldier or officer on duty in the rifle pit at target practice; a man who at target practice signals a miss when you are sure you have made a "Bull".

Sandstorm Division (Am.), the Thirty-fourth Division, composed of troops from Iowa, Minnesota, Nebraska and North Dakota. "Trained in Camp Cody, where sand storms sifted grit into almost every meal, they come by their name honestly." Insignia, red bovine skull superimposed on black field. The skull is said to be a conventionalized form of the Mexican water flask.

Sanniferan, same as San Fairy Ann.

sauce, petrol or gasoline.

***sausages,** I, observation balloons; II, slow aërial torpedoes. "At first we called them 'sausages', then 'rum-jars' (they resembled the ordinary one-gallon rum jar in size and shape), then they become 'flying pigs'." — McBride, *The Emma Gees*, p. 164.

sawbones (Am.), the regimental doctor.

Schützengrabenvernichtungsautomobil ("shooting-trench-destroying-automobile"), a humorous German name for tank.

***scooter,** a motor-driven hand-car for speed in reaching the various parts of the army supply bases in France. "The vastness of these depots is such that an inspection on foot or even in an automobile is out of the question. They are so criss-crossed with rails that you must use a 'Scooter', which is a motor-driven hand-car fitted for standard-gauge tracks. It took me nearly half an hour to travel over this plant at passenger train speed. Every important official has his own 'Scooter' and of course you see them scooting over the place at all hours of the day and night." — Marcosson, *S.O.S.*, p. 154.

scrap in: "We 'scrap in' before firing actual bullets. By that I mean that we go through all the science of firing; we adjust our windage, peep-sight, and elevation, each man according to the instruction of his card." — Catlin, *With the Help of God and a Few Marines*, p. 280.

***scrap of paper:** At the beginning of the war the British Government decided to make the violation of Belgium a *casus belli*. The German Chancellor hastened to Sir Edward Goschen, the British ambassador at Berlin, and made an appeal to have England disregard the Belgian treaty, referring to it contemptuously as a "scrap of paper".

It is interesting to note that when the German Chamber of Deputies protested to Emperor William I that the expenditure of funds without their sanction was a breach of the Constitution, the ruler dissolved the Chamber, and

boldly declared that he would do his duty without regard to "pieces of paper called constitutions". See *Harper's Weekly*, March 26, 1887, p. 226.

During the war a promise broken or a pledge disregarded was likely to be referred to as a "scrap of paper".

***scrounge,** to appropriate; to misappropriate. "In the category of 'odd jobs' came 'scrounging'. 'Scrounging' is eloquent armyese; it covers pilfering, commandeering, 'pinching', and many other familiar terms. You may scrounge for rations, kit, pay, or leave. Signalers are experts at it, and they usually scrounge for wire. Scrounging for wire is legitimized by the War Office, and called by the gentler name of 'salving'. We were informed that it was our duty to economize in the cost of the war by salving the wire that was disconnected by shell fire, or which appeared to be serving no useful purpose. We had first to 'tap it' on the line with a field telephone, and if we got no response the wire was ours. . . . We made 'scrounging' a daily affair, and not infrequently 'scrounged' wire that was *not* disconnected and belonged to other batteries." — G. Goodchild, *Behind the Barrage*, p. 94.

scuttled, captured.

sea dust (Am. N.), salt. *See* Chow slang.

sea gull (Am. N.), chicken. *See* Chow slang.

sea hornets, destroyers.

sea lawyer (Am. N.), I, a man who believed himself omniscient on things naval; II, a trouble-maker; a malcontent.

seabags (Am.), a type of large shell.

seconds (Am.), an extra helping of food.

Selborne's Light Horse (Br. N.), ordinary seamen, who, when Lord Selborne was First Lord of the Admiralty, entered the navy for a period of five years only.

selvooplonk, a vernacular form of the French, *S'il vous plaît*, "Please".

sentry go, time on guard.

shake a mean lip (Am. N.), to tell irresponsible stories; indulge in "a mean line of chatter".

shark-fin, a British type of hydrophone to detect submarines running submerged. *See* Nash-fish.

shave-tail (Am.), an officer who had recently graduated from West Point; any second lieutenant. In the Quarter-master Corps young unbroken mules were known as "shave-tails".

shell craters, holes made by exploding shells.

ship, airplane. The wings were frequently called decks.

ship another stripe: A flying-officer who was promoted was said to have "shipped another stripe". Nautical language was frequently adopted by the airmen. *See* Ship.

shirt hunt, a search for cooties.

shoestring corporal (Am.), a lance-corporal, who wears one stripe on his arm.

shore (Br. N.), the beach.

shore-loafer (Br. N.), a civilian.

***shorthorns,** *see* Mechanical cow.

shot away (Br. N.), drunk. *See* Drunkenness.

shots (Am.), inoculations.

***show:** "Anything in the nature of a thrust or a blow delivered against the enemy is a *show*. A great offensive on a wide front is a *big show;* a raid by night into hostile territory is a *little show;* a feint by infantry, undertaken with intent to deceive the other side at a given point while the real

attack is being launched at a second given point, and accompanied by much vain banging of powder and much squibbing-off of rockets and flares and star-shells, is a *Chinese show.*" — *Sat. Eve. Post*, May 25, 1918, p. 59.

shrapnel, grapenuts.

shutters, I, strips of colored canvas arranged on the ground in different formations by the Signal Corps to serve as a code for pilots flying overhead; II (Am.), camphor or opium pills.

Sick Bay, the ship hospital. *See* Galley.

Sick Bay Express, the Royal Naval Ambulance Train.

The train is considered a "ship" and a trip in it is a "voyage". "It is a case of going to 'Sick Bay' and 'Out pipes' at nine o'clock. They talk of 'darkening the ship' when the blinds are pulled and the lights covered." — M. Hall, *Some Naval Yarns*, p. 60. *See* Galley.

***sicker,** sick-report book.

side-kicker, sleeping companion; bosom chum.

sieda, socks. "One detects an oblique and wry fun in the professional army man's use of the word 'sieda' to mean 'socks'. (The new army more feebly dubs them 'almond rocks'.) 'Sieda' has been brought by the Anzacs from Cairo, and with them it means 'Good morning!' — a mere friendly hail, now used with great frequency. But the veterans of older expeditions in India and Egypt, when they had been on the march, took their socks from their perspiring feet and lay down to sleep; and in the morning — well, their socks said 'Sieda!' to them when they awoke, and were christened accordingly. Or again the socks (or other property) might have vanished in the night — in which case there had been 'hooks about' (pilferers about). If one of those 'hooks' were caught, he would be first 'rammed in the mush' (put in the guardroom), and then, if his guilt were established, he would be observed 'going over the wall' or 'going to stir' (going to detention prison)." — Muir, p. 228.

Siegfried, *see* Hindenburg Line.

Sighing Saras, shells.

Sighing Susans, *see* Silent Lizzies.

Sight-seeing Sixth (Am.): "This division is reported to have marched more than any other in the A.E.F. and was known as the 'Sight-seeing Sixth'." "The insignia is a six-pointed star in red, and is frequently seen with the figure '6' superimposed on the star, but that was never authorized." — *Nat. Geog. Mag.*, Dec., 1919, p. 514.

Signaler's Code: "When reading messages sent by any 'visual' method of signaling, such as flags, heliograph or lamp, it is necessary for the receiver to keep his eyes steadily fixed upon the sender, probably using binoculars or telescope, which makes it difficult, if not impossible, for him to write down each letter as it comes, and as this is absolutely required in military work, where nearly everything is in code or cipher, the services of a second man are needed to write down the letters as the first calls them off.

"As many letters of the alphabet have sounds more or less similar, such as 'S' and 'F,' 'M' and 'N' and 'D' and 'T,' many mistakes have occurred. Therefore, the ingenuity of the signaler was called upon to invent names for certain of the letters most commonly confused. Following is

a list of the ones which are now officially recognized:

A	pronounced	ack
B	"	beer
D	"	don
M	"	emma
P	"	pip
S	"	esses
T	"	tock
V	"	vick
Z	"	zed

"The last is, of course, the usual pronunciation of this letter in England and Canada, but, as it may be unfamiliar to some readers, I have included it.

"After a short time all soldiers get the habit of using these designations in ordinary conversation. For instance, one will say: 'I am going over to esses-pip seven,' meaning 'Supporting Point No. 7,' or, in stating the time for any event, 'ack-emma' is A.M. and 'pip-emma' P.M.

"As the first ten letters of the alphabet are also used to represent numerals in certain methods of signaling, some peculiar combinations occur, as, for instance: 'N-ack-beer' meaning trench 'N-12,' or 'O-don' for 'O-4.'

"'Ack-pip-emma' is the Assistant Provost Marshal, whom everybody hates, while just 'pip-emma' is the Paymaster, who is always welcome. Thus, the Machine Gunner is an 'Emma Gee' throughout the army." — H. W. McBride, *The Emma Gees*, in prefatory matter (pages unnumbered). Indianapolis, The Bobbs-Merrill Company, 1918.

Silent Division, taciturn New Zealanders.

Silent Lizzies, "Sighing Susans", and "Whispering Willies" were large-caliber, long-range naval-gun shells which passed over the front lines at a velocity so high that one hardly heard them in their flight.

Silent Service, the Navy. This is a reference to the long silent vigil of the British Fleet.

Silent Sue, a shell which gave no warning of its approach; "rubber heels".

sinkers (Am.), dumplings; doughnuts.

sitting on his tail, the operating of an airplane so that it maintained a course just above and back of an opponent, a maneuver which gave opportunity to shoot away the enemy plane's controls.

six bob a day (Br.), the six shillings per day of men specially enlisted on the outbreak of the war.

sixteen to one, milk.

***skipper,** I, the squadron commander in the Royal Naval Air Service; II (Br. N.), the commanding officer of a vessel.

***S*lackers' *P*aradise Boats** (Am. N.), an ironical allusion to the *S*(ub) *P*(atrol) Boats.

slang from the Russian: "Chief of these words is *Skolkea*, of which the English equivalent is *How much?* The Yanks have been using this word on the Russian population ever since they landed (Sept., 1918) in transactions of barter and sale. The soldiers have made a verb of it, and those who have made neat profits in selling cigarettes, old clothing, superfluous rations, etc., to the peasant city civilians are spoken of as having *skolkea-ed* something. Other words which the soldiers have adopted as their own include: *Ponimiyu*, meaning *I understand*, and *ne-ponimiyu*, meaning *I don't understand; Da* meaning *Yes; Nyet* meaning *No; Spasebo*, meaning *Thank you.* And last, but not least, the eternal Russian *Nichevo*, which means

anything from *Nothing, Never mind,* to *What do I care about that?*" — Correspondence of the Associated Press, July 5, 1919.

slip trenches, blind alley-ways leading off from the main trench, with room for from ten to fifteen men in each. See J. N. Hall, *Kitchener's Mob,* p. 80.

Sloper (Am. N.), one who hails from the Pacific Coast.

slum (Am.), a stew composed chiefly of meat, potatoes and onions. The cadets at the United States Military Academy used to refer to hash as "slumgudgeon".

slumgullion, army stew.

Smash the Hun, a slogan of the American fleet.

***Smoke, The,** a name given to London by Colonial troops because of the heavy mist and smoke-like fogs that hang over it. "Big smoke" was a common designation.

smoke a thermometer, to have one's temperature taken.

Smoked Yankees, Negroes.

smoke-wagons (Am.), guns of the field artillery.

snaffer, "which means 'Please don't trouble', is derived from the polite *Ça ne fait rien* of the farmer's wife when Mr. Atkins apologized for inflicting some trifling inconvenience". — *The Illustrated London News,* Jan. 4, 1919, p. 6.

snake eyes (Am. N.), tapioca. *See* Chow slang.

Snap out of it, get out of your bunks. "The captains transmitted their orders to their respective companies by a wave of their hands, while the sergeants and corporals emphasized the command to rise with sharp injunctions to 'Snap out of it!', 'Hit the deck!', 'Rise and shine!', and other such nautical tricks of expression, all of which were traditionally sacred in this organization (the U.S. Marines), which, entrained or afloat or afield, never permitted itself to forget that it was essentially a sea-faring set of men." — *Sat. Eve. Post,* Dec. 21, 1918, p. 29.

sneezing gas, a German gas which discomfited men and rendered them temporarily useless by causing fits of sneezing.

Snipe, a Sopwith type of airplane brought out in 1917.

sniper, a concealed sharpshooter whose duty it was to pick off (or "pot") enemies.

snipes (Am. N.), firemen in the "black gang". "In a gang of snipes below, there is generally one dude who is known as the 'king snipe'." — Ruggles, p. 139.

snow digger (Am. N.), a man from the New England States.

Soap-suds Row (Am.), the laundresses' quarters.

so-called salts, *see* Dry-land sailors.

soldier (Am.), to serve; to shirk.

soldier's one per cent (Am.), one hundred per cent.

solo-hop, a flight alone. *See* Solo flight, in Fraser and Gibbons.

soloing, flying alone.

Somewhere in France, a place the exact location of which was known to a few members of Entente Nations — and to the German High Command.

Sopwith Strutters, a type of airplane used effectively by the British in 1916 at the Battle of the Somme. They were fitted as two-seater fighters, with the gunner in the back seat.

sound scoff (directions to the bugler), sound rations.

soup guns, rolling kitchens.

***souvenirs,** shells.

Soviet, a Russian council composed of Workmen's and Soldiers' dele-

gates. The word *soviet* means both council (like Latin *concilium*) and counsel (like Latin *consilium*).

sow-belly (Am.), bacon.

Spartacides, a party of extreme German Socialists led by Dr. Liebknecht and Rosa Luxembourg, who wished to see a proletarian government set up in Germany. It is said that the name is derived from the fact that early in the war Dr. Liebknecht issued a number of anti-war pamphlets signed with the pseudonym "Spartacus". The choice of the name was due to the fact that the revolutionists of 1848 had a partiality for signing their anonymous pamphlets with classical names, a habit which the Liebknecht group revived.

Spartacus, it will be recalled, was the Roman slave who led the servile insurrection against the Romans, 73–71 B.C.

In the word Spartacides, the *-des* is a Greek patronymic meaning "sons" or "descendants". It should, strictly speaking, be pronounced as a separate syllable. When *-cides* is pronounced as one syllable, it seems to imply a connection with the Latin word *caedo, caedere,* "to kill". (In compounded forms the *ae* of *caedere* becomes *i*.) "Spartacans" is a much more natural formation.

See, however, Smith, pp. 176–177.

Spick (Am. N.): "A Mexican or Spaniard, or any dark-skinned people are known to the navy men as *spicks*. It was, some years ago, almost always called *spiggoty*, but since the days of abbreviations, *spick*. The term is said to have originated during the Spanish-American War." — Ruggles, p. 140. The term was used in the army also, especially on the Mexican border.

spider webs, wire entanglements.

spikebozzle, a term applied to airplanes trying to destroy Zeppelins, or any enemy airship.

splash, the tankman's term for splinters flying from bullets impinging upon his machine. "While bullets do not penetrate the armor (of tanks), but only ruffle it up a bit at the point where they are deflected, a great deal of bullet 'splash' does come in. This is more annoying than serious, and after an action one could pick out any number of these tiny splinters from one's face. So, as a means of protection against 'splash', face-armor was invented. This looks much like a bandit's mask, with a steel-mesh chain hanging from it. The mask itself is of thin steel, with slits for the eyes, the whole padded for the face and adjustable to it." — *The Atlantic Monthly,* Dec., 1918, p. 847.

splitass, to do stunt flying, or to fly in a reckless manner.

splitass merchant, an expression applied indiscriminately to a reckless individual, or to a really good flyer capable of executing stunts with a modicum of safety.

spotted dog (Br. N.), pudding.

spotters, I, men who telephoned the ranges to the gun crews; II, airmen engaged in locating guns or submarines.

spruce, to deceive. "A man who contrived to slip out of the ranks of a squad when they were performing some distasteful task would be said to 'spruce off'. Or he would be denounced as a 'sprucer' if he managed to arrive late for his meal and yet, by a trick, to secure a front place in the waiting queue at the canteen.

A word in constant employment, 'spruce'." — Muir, p. 230.

sprucer, *see* Spruce.

spud-hole, the guardroom.

spud-squad (Am.), potato peelers.

***spurlos versenkt:** In a telegram dated May 19, 1917, Count Luxburg, Germany's representative to Buenos Aires, begged that two Argentine ships then nearing Bordeaux should be spared or else sunk without a trace being left (spurlos versenkt). After this message was disclosed, there was a tendency to make it a kind of byword, but it soon died out.

***Square head,** a German. This is a translation of the French expression, *tête carrée.*

square push (hospital slang), a girl.

square-push tunic (hospital slang), the tunic for promenade occasions.

squaring, buying favors.

stable police, men detailed for work in the stables.

staggered: "The M. Farman machine is a large biplane with tail plane and rudder behind, but with an elevator carried on a framework in front. In one type the main planes are 'staggered', which means that one of them (the upper one) is somewhat in advance of the other." — T. W. Corbin, *Aircraft, Aëroplanes, Airships,* p. 73.

***stand-to,** "the name given to the sunrise hour, and again that hour at night when every man stands to the parapet in full equipment and with fixed bayonet. After morning stand-to, bayonets are unfixed, for if the sun should glint upon the polished steel, our position would be disclosed to some sniper." — H. R. Peat, *Private Peat,* p. 92.

star lights, flares.

star shells, rockets to light up No Man's Land at night.

Stars and Stripes (Am.), beans. This dish was evidently so called because of the striped appearance of the bacon served with the beans.

stone frigates (Am. N.), prisons ashore. The name is due to the fact that worn-out boats were once used as prisons.

Stonewall Division, the Eighty-first Division. *See* Wild Cat Division.

storm-cellars (Am.), dugouts.

***strafe** (from German *strafen,* "to punish"), to bombard. Originally meaning "punish", the word was finally so greatly extended that Tommy could speak of "strafing" a fly. The word is used also as a noun, e.g., "Next strafe we 'ave, 'ell's goin' to pop for fair."

straff, a variant of "strafe".

straggler barrage, a cordon of military police who followed the infantry over the top and nipped in the bud any attempts at straggling toward the rear.

straight bake (Br. N.), a joint of meat baked by itself.

straight kick (Am. N.), a summary discharge by the commander of a vessel. At times a man may be set on the beach without formality. See Ruggles, p. 135.

strategic retreat, the German High Command's explanation of the retirement from the Somme in the spring of 1917. During the following year there was a tendency to give the expression a slang connotation, and to use it when a person yielded a point or receded from a position he had taken.

strawberries, prunes.

striker (Am.), a soldier who works for an officer; "dog robber".

submarine shark (Am. N.), salmon.

submarines, urinals, "ducks".

Sugar Sticks, Army Ordnance Corps.

***Suicide Club,** Machine Gun Corps. "During the early part of the war, before the advent of the Lewis and other automatic rifles, the only machine guns in general use were of the heavy tripod-mounted type and it was necessary for them to advance with or even ahead of the attacking troops. As the guns and tripods were very conspicuous objects, they naturally became the especial targets for enemy riflemen and snipers and the casualties ran far above the average for other troops." — McBride, *The Emma Gees*, p. 50.

Suicide Fleet, the small boats of the Patrol Squadron in European waters. "In boats that were never expected to fight, the largest of them hardly more than seven hundred tons gross, many of them so delicately balanced that the weight of the single gun they had to carry was almost enough to turn them topsy-turvy, any of them sure to be instantaneously distributed over the sea if touched by a torpedo, life is likely to be a precarious and brief matter." — *Lit. Dig.*, March 22, 1919, p. 58.

Suicide Squadron (Am.), the flotilla of American warships which laid the North Sea mine barrage.

Sun has come over the foreyard, The (Br. N.), It is time to have a drink.

Sunset Division (Am.), the Forty-first Division, composed of troops from Washington, Oregon, Idaho, and Wyoming. Insignia, a setting sun of yellow on a field of red.

Sunshine Division (Am.), the Fortieth Division, composed of troops from Arizona, California, Colorado and Utah. Insignia, a shining sun of gold on a blue field.

Swabos: "By this name Serbian soldiers designate their opponents, implying that only Swabians are employed in the Austro-Serbian campaign." — *Notes and Queries*, Dec., 1914, p. 507.

swaddy (Br. N.), a soldier.

swagger (hospital slang), a tunic for promenade occasions; 'square-push' tunic.

sweating, getting warm; approaching success. Sweating is a term "frequently used in the favourite game 'house', where each player buys a card on which are printed three rows of figures. Counters bearing other figures are extracted from a bag, and the players cover up the numbers that appear on their respective cards as the numbers are called out. When a player has completed any horizontal line in this way, he calls 'House', and takes the pool (the money paid for the cards). When he needed one number only to complete a line, he was 'sweating on' that number. It is easy to understand why the prospect of winning a substantial sum causes him literally to sweat. Thus 'sweating' has come to mean 'to be within an ace of securing', or 'to have a reasonable hope of attaining'. A corporal may be said to be 'sweating on' sergeant, that is, he has reasonable hope of shortly becoming one. In connection with leave, it is frequently employed to indicate prospects. Thus, 'Had your leave?' 'No, but I am sweating', or, 'No, I am not even sweating'." — *Notes and Queries*, March, 1919, p. 79. *See* Sweating on the top line, in Fraser and Gibbons.

swill, salvage.

Switch, The, the Wotan Line, which was a switch of the Hindenburg Line.

T

tailor-made, cigarettes bought ready-made.

take another blanket (Am.), to re-enlist before the expiration of three months after discharge.

take on (Am.), same as Take another blanket.

takin' the beach (Br. N.), going ashore for an hour or two.

Tangos, a crack German escadrille, so called because of the color of their machines, tango orange.

tank, I, wet canteen; II, an armed and armor-plated motor car.

Colonel Swinton, the inventor of the tank, explains the origin of the name in *World's Work* for Sept., 1917, p. 570: "Quite a large part of the earlier stage of manufacture would consist of the rolling of steel plates and their assemblage and erection into boxes, which to all except those who made a close examination might well be intended for vessels to hold water, petrol, or oil. The fact that the boxes would be bullet-proof would merely lend color to the idea that they might be intended to move up into the fighting zone. This theory would not necessarily be discredited even when the stage of fitting them with engines and caterpillar tracks was reached. It would not be until the time for mounting the armament that the real purpose must become plain, up to which an *alias* might to some extent conceal it. 'Reservoir' and 'Cistern' were long-winded and clumsy; 'Tank' was equally accurate and shorter. And 'Tank' it became. As a matter of fact, various rumors about the new machines were current among those who got wind of them. One was that they were intended to carry water for the troops across the deserts of Egypt and Mesopotamia. A second hinted at snow-ploughs for use on the Russian front. It is perhaps unnecessary to say that no special trouble was taken to contradict these yarns. It was also bruited about that experiments had been made in some wild-cat scheme which had failed absolutely."

"Up to December 1915, the machines now known as 'tanks' were, in the experimental stage, called 'landships' or 'land cruisers,' and also 'caterpillar machine-gun destroyers.' On December 24, . . . it occurred to Colonel Swinton that the use of the above names would give away a secret which it was important to preserve. After consultation with Lieutenant-Colonel W. Dally-Jones, assistant secretary of the 'Committee on Imperial Defence,' the following names were suggested by Colonel Swinton — 'cistern,' 'reservoir,' and 'tank,' all of which were applicable to the steel-like structure of the machines in the earlier stages of manufacture. Because it was less clumsy and monosyllabic the name 'tank' was decided on." — Brevet-Colonel J. F. C. Fuller, *Tanks in the Great War*, p. 29.

"The British tanks, as first produced, were of two types, male and female. The male tank was armed with two six-pounder, rapid-fire Hotchkiss guns, and four Lewis machine guns, and these were used against the more formidable defenses, such as concrete-lined redoubts and the

famous 'pill-boxes'. The female type carried a lighter armament of six Lewis guns, and they did great execution by straddling the trenches and enfilading the enemy with a sweeping fire, to which the Germans could make no reply." — *Review of Reviews*, Oct., 1918, p. 383.

Among nicknames for types of tanks are Baby, Big Willie, Little Willie, Crocodile, Humming Bird, Rhino, Whippet. Many tanks had individual names such as Delphine, Daphne, Delsie, Cordon Rouge, Crème de Menthe.

tanked to the wide, drunk. *See* Drunkenness.

***tank(e)y** (Br. N.), the assistant midshipman of the Navigating Lieutenant. *See* Tanky, in Fraser and Gibbons.

tank-wallah, a drinker. *See* Wallah.

taped off, said of a man whose "measure" has been taken.

taped out, an expression applied to a strip of land upon which the German gunners had accurately registered distances. *See* Tape, in Fraser and Gibbons.

taxi, to drive an airplane on the ground without rising into the air; to run along the ground in order to acquire sufficient speed to ascend.

T-bone steak, tenderloin steak.

tea-kettle (Am.), French locomotive.

tear shells, shells which make the eyes smart or cause tears.

Tell it to the Marines (Am.), "an old army phrase used when a man is trying to get away with a fishy statement. The marine is half soldier and half sailor. He generally receives his preliminary training on land; after that, on a ship. Upon arriving on board the sailors tell him many impossible tales and he is supposed to believe them". — Empey, *First Call*, p. 363. In spite of the origin and meaning of this expression, it was employed in recruiting posters in the slightly altered form, *Tell that to the Marines.*

Terribles, Les, "The Terribles", a Poilu name for the Thirty-second Division of the U. S. Army. *See* Broad Arrow Division.

tethers, cables mooring captive balloons.

Teufel-hunden, a mistake on a Marine recruiting poster for *Teufelshunde*, "Devil Dogs," the German nickname for the U.S. Marines.

third lieutenants (Am.), *see* Dovetails.

three beans, a soldier's representation of *très bien.*

three-point landing, said of the landing of an airplane when both wheels and the tail hit the ground at the same time.

three-thirty (Am.), three months in the guardhouse and thirty dollars fine.

thumbs up, everything is fine with me. It is a popular idea that the Roman populace held their thumbs up, when a defeated gladiator was to be spared, but classical scholars are by no means unanimous on this point.

tick one off, to administer a reproof. "Click" was used at times in the same sense.

Ticklers' Artillery, a bombing squad. *See* Ticklers in Fraser and Gibbons.

tie bags with (Am. N.), to get married. The expression originates from the fact that chums used to tie their seabags together on the same jack stay. In the old navy, *to tie bags with a man* meant *to hang out with him.* From this use it was extended.

Tiger, Premier Clemenceau of

France. This name was given to him because of his aggressiveness.

Tiger cats (Am.), heroes of Château-Thierry.

***Tigers,** Alabama soldiers in the 167th Regiment of the Rainbow Division. The name was given to them by the French at whose side they fought in Champagne in July, 1918.

tin derby, helmet.

tin dip, helmet.

tin-fleet (Am.), pleasure boats refitted and armed as submarine hunters.

tin-hatted (Br. N.), drunk. *See* Drunkenness.

tinned cow, condensed milk.

***toasting-fork,** bayonet. *Compare* Fr. *tourne-broche.*

toffy apples, huge bombs into which were inserted long rods or pipes, so that they resembled toffy (or taffy) apples.

Tommy, the familiar name of Tommy Atkins.

***Tommy Atkins,** the British soldier. He was familiar to readers of Kipling long before the war. *Barrack-Room Ballads* is, in fact, dedicated "To T. A." One stanza of *Tommy* runs as follows:

> While it's Tommy this an' Tommy that, an' "Tommy, fall be'ind,"
> But it's "Please to walk in front, sir," when there's trouble in the wind,
> There's trouble in the wind, my boys, there's trouble in the wind,
> O it's "Please to walk in front, sir," when there's trouble in the wind.

The *Phila. Public Ledger* (Aug. 24, 1919) thus explains the origin of the name: "It happened in this way. The war office issued a little note-book to the men requesting each one to fill out the little blanks in the front as to name, age, date of enlistment, etc. So that they would not make any mistakes a copy of the front page was filled out properly in each book under the name of Tommy Atkins. It did not take long for the name to stick to all the soldier boys, and it is today as significant of the English fighting man as John Bull is of England itself."

tootfinny, a vernacular form of the French, *tout fini,* "everything done".

***toothpick,** bayonet. This is in imitation of the French *cure-dent,* toothpick, "bayonet".

top cutter (Am.), first sergeant.

Top Hats at Home, Tommy's name for Parliament when he was displeased with it.

top kicker (Am.), first sergeant. As a rule, the top kicker does not handle his men with any more care than he does his English. At reveille, for example, he routs the men out with such remarks as these: "Jar loose, you guys!", "One foot on the floor!", "Burning daylight?", "Where do you think you are at, the Grangers' picnic?"

top sergeant (Am.), first sergeant.

top soldier (Am.), first sergeant.

Top your boom (Br. N.), clear out; your room is preferred to your company.

torp, a torpedo.

tot, the regular ration as served after a cold "sentry-go".

toy shop (Am.), the factory in France where papier-mâché soldiers and various camouflaged objects were made.

***tractor,** an airplane whose propeller buzzes in front. When the propeller is behind, the machine is known as a "pusher".

Trade, The (Br. N.), the submarine service. See Smith, p. 190.

trench derby, helmet.

***trench feet,** a disease of the feet contracted in the trenches from exposure to extreme cold and wet.

"In winter, when the water was ice cold, it may be imagined what our men endured. They were always wet. They slept in wet clothes, sat in wet dugouts, stood in wet boots, and the cold slime of mud in Flanders encased them, and put its clammy touch about their very souls. In the first two winters of the war, they were stricken with a disease called 'Trench Foot'. Its symptons were exactly like those of frost-bite, a sense of burning until all sense was deadened and the feet blackened and rotted. Battalions lost 40 per cent of their men for a time from this cause, and in the old Ypres salient I have seen men of the 49th (Yorkshire) Division crawling back from the trenches, or carried pick-a-back by their comrades, unable to walk a yard, and with both feet tied up in cotton wool at the field ambulance." — P. Gibbs, *The New York Times,* April 6, 1919, § 4, p. 1.

trench moppers, grenadiers hunting for concealed Germans in German trenches.

trench mouth, a disease that causes ulceration and bleeding of the gums.

"We have trench mouth just as we have trench feet. Otherwise known as ulcero-membranous stomatitis, or Vincent's disease, it has for some considerable time now, engaged the attention of both the medical and the dental services. The result of a bacillus that causes ulceration and bleeding of the gums, it occurs on the German as well as on our side of the war zone. A satisfactory method of treatment has been discovered, the painting of the gums with salvarsan or an arsenical solution, and a cure is generally effected within two or three weeks' time. The Germans credited their war bread as one of the contributory causes, a cause that up to the present is absent from the British war zone." — *The Mail* (London), May 1, 1918, p. 3.

tres bon, a vernacular form of the French *très bien,* "very good".

tres bong, same as *Tres bon.*

trick, one's turn at sentry-go. The word was borrowed from seamen's language in which it meant one's turn or period at some task or duty.

tube, a kind of dugout. "If you took half a subway car, stuck it in the ground, and covered the top with two or three feet of earth, you would have a 'tube' dugout. Inside are seats as in the subway, and through the center runs a rudely constructed table." — J. S. Smith, *Over There and Back,* pp. 201–202.

tuning up, final inspection and adjustment of the parts of an airplane before flying.

***Turkey,** a Turk. *See* Abdul Pasha.

Turkish delight, the Newfoundlanders' name for shrapnel in the Gallipoli campaign.

Turk's Head Pier, a tiny wooden jetty built by the Engineers. See Hargrave, *At Suvla Bay,* p. 50.

Turn off the juice, shut off the engine. "Juice" is a fairly common designation of gasoline.

Turn the mill, start the motor.

two ends and the bight of a fool (Br. N.), a consummate fool. The bight of a rope is the loop between the ends.

two-and-a-half-striper (Br. N.), the first lieutenant, so called from his

badge, two wide rings and one narrow one of gold lace on the cuff. Ruggles states (p. 146) that in the American Navy the expression means "lieutenant commander".

two-o'clock (Am.): In target practice the results of shots are indicated by "clock-face" designations, as "one-o'clock", "two-o'clock", "three-o'clock", etc., since this method is simpler and much more readily comprehended than scoring by the number of degrees.

two-spot, *see* Grass-cutter.

two-winger, a pilot who wore the Royal Field Corps two-winged badge.

typewriter, I, a machine gun; II (Am.), lawnmower. Officers used to ask how many soldiers could operate a typewriter. Those who responded found that the "typewriter" was a lawnmower.

U

U-jah, same as Cum-sah.

Uncle Charley, an affectionate name given by the Twenty-eighth (Pennsylvania) Division to its commander, General Charles H. Muir.

under the truck (Br. N.), angry.

up in the riggin' cheering ship (Br. N.), holding a heated argument while under the influence of liquor.

***up the line,** the expression "generally used in rest billets when Tommy talks about the trench or fighting line." — Empey, *Over the Top,* p. 313.

up the pole, drunk. *See* Drunkenness.

upstairs, the flying man's term for "in the air".

Upton Division (Am.), the Seventy-seventh Division, so called because it trained at Camp Upton, Long Island. *See* Liberty Division.

V

Very lights, a kind of flare fired from a pistol; named after the inventor.

vipers, fast little airplanes which guarded reconnaissance machines from overhead, underneath and on the sides; "maggots".

Von Woodenburg, a take-off on Von Hindenburg. "We would inquire after the health of old 'Von Woodenburg', old 'One O'clock', the 'Clown Prince', or 'One Bumstoff'." — H. T. Peat, *Private Peat,* p. 107. These parodies refer to Von Hindenburg, Von Kluck, the Crown Prince and Von Bernstorff.

voyage, *see* Sick Bay Express.

vulture (Am.), *see* Goopher.

Vun O'clock, a parody on Von Kluck.

W

waders, hip-boots.

wagon-soldiers (Am.), light- or field-artillerymen.

***wallah,** a fellow. A dandy is a *pukkawallah,* a thief is a *loose-wallah.* "Wallah. — Wala, properly agent, one who does or possesses, a person; commonly used in composition like the English suffix, –er, e.g., doer." — *Notes and Queries,* Dec., 1918, p. 333. This was one of Tommy's Hindustani words. *See* Indian words.

warts (Br. N.), junior midshipmen.

washed out, killed.

***wash-out** (Br. N.), a failure. This expression has crept ashore and into the army.

"It is one that has been used in the Navy from the first days of the use of signals, when they were taken down on a slate, and,

after having been read and acknowledged, were rubbed off the slate with a damp rag. 'Wash out!' cried the signalman then to the signal-boy. 'Wash out!' he cries to-day, too. Hence the phrase 'It's a proper wash-out', complete finish, complete failure, also, and of no good." — Vaux, p. 59.

"At the end of the week you will be given an examination. Those who do well will remain with the tanks; the washouts will go back to the infantry." — *The Atlantic Monthly*, Jan., 1919, p. 81.

wave, a line of men advancing side by side.

wax dolls, girls.

***Weary Willies,** German shells. These shells are said to have a "nerve-racking whine".

weazels, girls.

web-foot, an occasional name for the infantryman.

weighing out, paying out.

well sprung, drunk. *See* Drunkenness.

west, *see* Go west.

Western Division (Am.), the Eighty-ninth Division, composed of troops from Colorado, Kansas and Missouri. Insignia, a black monogram "MW" (Middle West) on khaki. *See* Jayhawkers.

wet and warm, tea. This use was evidently due to the habit of taking tea for refreshment when one was wet and warm. *Compare* Hot and dirty.

wet-nurse (Am.), a colloquial or quasi-technical term employed by army men to describe the tests of a gun in the arsenal or on the proving-grounds under the special direction of the inventor or promoter. See *The Outlook*, Jan. 30, 1918, p. 180, n. 1.

whacked, exhausted; played out.

what-for: "To give an enemy 'What-for' was to play the very mischief with him." — *The New York Times*, March 2, 1919, § 4, p. 1.

whees, an onomatopoetic name for big shells.

***whippet,** a small, fast, and mobile type of British tank named after a breed of dogs originating among the colliers of northern England and used chiefly for coursing and racing. The dog is thus described in *The National Geographic Magazine* for March, 1919, p. 208: "A small and very swift breed of greyhound called the whippet has been developed in England, and whippet racing is an old and favorite sport among English workingmen, particularly in the northern and northeastern counties. The dogs are raced over a 200-yard straight-away course, and are usually handicapped according to weight and previous performance. . . . The ideal weight is about 15 pounds for males and 13 for females."

Whispering Jimmy, a howitzer shell.

Whispering Willies, large German shells which traveled at a velocity so high that one hardly heard them in their flight. *See* Silent Lizzies.

White Chimney, an Anglicized form of *Huit Chemins.*

White Ghurkas, a name applied to the Canadians by the Germans.

White Guards, Bourgeoisie. *See* Guards.

white hopes, German high-explosive shells.

white lightning (Am.), corn whiskey; "white mule"; "gray mule".

white man: "In the army it is a term of supreme praise to call a man *white.* When you say a comrade is a *white man,* there is no more to be said. It is worth

more than the Victoria Cross with its red ribbon, for it includes gallantry, and adds to it goodness. A man must be brave to be called *white*, and he must be generous, noble and good. To reach whiteness is a great achievement. To be dubbed white is, in the army, like being dubbed knight at King Arthur's Court, or canonized saint in the Church. He stands out among a soldier's comrades distinct as white handkerchiefs among khaki ones." — T. Tiplady, *The Soul of the Soldier*, p. 55.

white mule (Am.), corn whiskey; "gray mule"; "white lightning". This concoction is called "white mule" because of its color and its "kick".

white swans, German high-explosive shells. The name is explained by the puffs of white smoke which floated in the air.

***whizz-bang,** an onomatopoetic name for a heavy shell. "The 'whizz-bang' starts with a rough whirr like a flushing cock partridge, and goes off on contact with a tremendous bang." — Holmes, p. 89.

whutt, an onomatopoetic description of a bullet. "When a bullet whistles or sings past, it is a comfortable distance clear; when it goes *hiss* or *swish*, it is too close for safety; and when it says *whutt* very sharply and viciously, it is merely a matter of being a few inches out either way." — B. Cable, *Between the Lines*, p. 150.

widders, girls.

Wild Cat Division (Am.), the Eighty-first Division, composed of men from Florida, North Carolina, South Carolina and Porto Rico. The name has also been frequently applied to the Thirtieth (Old Hickory) Division, because the men in it came largely from the same states. The name is due to the fact that a small stream which flows through Camp Jackson, S.C., where the unit was organized, is called Wildcat Creek. Insignia, a cat on a disc. The color of the cat varied according to the brigade.

wild cat trains, trains that the Belgians sent wild into the German lines outside Antwerp at the beginning of the war.

Wild West Division (Am.), the Ninety-first Division, composed of troops from Alaska, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. Insignia, a green fir tree.

wild woodbines, cigarettes "composed of glue, cheap paper, and a poor quality of hay". — Holmes, *A Yankee in the Trenches*, p. 59.

will-o'-the-wisps, shells.

***win,** to steal; to lift; to "scrounge"; to obtain by other than fair means. "I won it", was a common expression in the trenches.

***windjammer** (Am.), a trumpeter; bandsman.

wind-up, perturbation; fear; cowardice. "A Bulgar or Hun soldier near by gets a colossal wind-up at sight of us diving on him, and hares down the side of the field in great style." — *Blackwood's*, Oct., 1918, p. 528.

wing-tip flares, magnesium lights placed under the bottom of night-flying airplanes; used only for landing at night.

Winston's Own, *see* Dry-land sailors.

Wirepullers, Royal Engineers.

wolf, a dare-devil pilot who did stunts near the ground (*for a short time!*).

Wolverine Division (Am.), the Fourteenth Division. It was so named because wolverines were once very common in Michigan, where the division was organized.

The head of a wolverine appears on the insignia.

***woodbines,** cigarettes made of paper and old hay.

wood-butcher (Am.), company artificer.

***woolly bear,** a shell which on exploding gave out a dense black smoke and rolled about in such a manner as to suggest the animal for which it was named.

Woolly Marias, shells.

***working one's ticket,** getting some illness or injury on account of which one was sent back home to a hospital.

Wotan Line, *see* Hindenburg Line.

Y

Yank Tommies, American soldiers in the British Army.

Yankee Division (Am.), the Twenty-sixth Division, composed of New England troops; called also *New England Division.* Insignia, a dark blue "YD" monogram on a khaki diamond.

Yellow Cross Division (Am.), the Thirty-third Division, composed of troops from the National Guard of Illinois. The name is derived from its insignia, a yellow cross on a black circle. The colors of this division were due to the fact that only yellow and black paints were available when it became necessary to mark the equipment in Texas before leaving for France. *See* Illinois Division.

yellow ticket (Am.), a dishonorable discharge. The paper was yellow.

yellow-leg (Am.), cavalryman.

youngster (Am.), a young officer, a first or second lieutenant.

Z

Zeppelins in a cloud (Br. N.), sausage and mashed potatoes; "sausage and mashed".

***zero,** the time fixed for an attack. The time before or after was spoken of as *plus* or *minus zero.*

zero day, the day for an attack.

zing, "pep"; "vim".

***zoom,** an airman's term for climbing at an extreme angle for a short distance and then resuming a level course before the machine stalled. "My trouble now was to 'zoom' over the fringe of trees and fences. There was a heart-breaking moment when I thought that I was going to be 'hung up' on a tall tree-top, but the gallant old girl rose to the occasion, and the leaves seemed just to graze my wheels. I breathed a stupendous sigh of relief."—*Century,* Jan., 1919, p. 381.

Zouave (Am. ambulance), the cook.

LITERATURE ON WAR SLANG

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A CRITIQUE OF STATISTICAL THEORY AS APPLIED TO EDUCATIONAL AND INTELLIGENCE TESTS

CARL R. BROWN

THE concept of measurement has long played an important rôle in scientific investigation. Indeed, it would appear that there is a general feeling that a "science" that does not make extensive use of measurement somehow falls short of being truly a science. Many psychologists have apparently accepted this notion and have resolutely applied themselves to the business of making "measurements," but with no clear conception of the quantity "measured" and often without serious attempt to formulate the problem attacked. Such haphazard activity is doubtless a normal phenomenon in the early stages of development of any science, particularly when the complexities are as great as those in the field of psychology. But rehabilitation of concepts and definitions is necessary at frequent intervals to avoid the stagnation that would otherwise result.

It is my purpose to attempt a brief critique of certain concepts that appear to be fundamental to the statistical theory of psychological phenomena, particularly those with which educational and intelligence tests have to do.

If we turn our attention, humbly and not too enviously, to the physical sciences which owe their remarkable successes in large part to highly refined and rigidly defined concepts of quantity supported by adequate techniques of measurement, we observe that all quantities are measured in terms of independently defined units, except only the fundamental kinds of quantity, mass, time and length. Velocity, acceleration, force, energy, etc., are measured in units which are defined in terms of the three fundamental dimensions, and therefore independently of

the velocities, accelerations, forces, etc., that require measurement in a particular experiment. Moreover, all scales are homogeneous, i.e., the units are identical both qualitatively and quantitatively, and may be said to be mutually interchangeable.

May the concept of measurement that has developed in the physical sciences, implying units possessing the two properties of independence of definition and mutual interchangeability, be transferred to the domain of psychological phenomena? This is an old question about which much controversy has arisen. But controversy may be avoided by remaining close to the facts. And if the facts be taken at their face value it becomes clear that a distinction needs to be made between measurement and counting. Measurement obviously involves counting, for measurement of a given quantity is clearly a matter of counting the members of a set of smaller, quantitatively and qualitatively identical quantities which in the aggregate are equivalent to, and interchangeable with, the given quantity.

The converse does not hold, however. One may count without thereby achieving measurement, and this is clearly always true when the things counted are not mutually interchangeable. Thus I may count the coins in my pocket, but the result is practically meaningless and falls too far short of being a measurement to be regarded as even a rough approximation.

The score which a person earns in a test is primarily an enumeration. Moreover, it is not an enumeration of things but of events. These events have occurred in sequence and the antecedent conditions of each event have differed from those of the other events. Each event has differed from each of the others. Manifestly it is absurd to regard an enumeration of such a sequence of events as a measurement. Further, it is futile to suppose that an enumeration, recognized as such, indirectly measures a quantity until the form of the function connecting the two variables is known. In the absence of such knowledge any one of an infinite number of different assumptions is possible. The assumption customarily, though tacitly, made, that of simple proportionality, is purely gratuitous and possesses the questionable virtue of simplicity only.

The statistical machinery in present use for the analysis of intelligence and educational test data has been taken over uncritically from the field of morphological statistics. In this field one is dealing with genuine measurement, for the units employed are the physical units of mass, time, and length, and fulfill the logical requirements of independence of definition and interchangeability. Of course, the interpretation of such measurements of biological quantities raises many difficult questions, but we are not concerned with these at present. The fundamental question is whether the statistical theory of measurable quantity is applicable to countable events. Boring,[1] after a careful examination of the logical foundations of such theory, came to the conclusion that it is not. The position taken here, based upon considerations having much in common with those of Boring, is one of complete agreement with his, up to the point of a proposed substitute for the statistical methods now in use.

Boring's conclusion was that orders of merit, medians, quartiles, and related statistical constants only were logically defensible. But he was apparently still holding to the conception of quantity, measurable in principle but not in fact, owing to uncertainty as to the choice and definition of units. If, however, the concept of quantity is given up, and if in its place is put that of enumerable and classifiable events, there results an extension of the scope of statistical analysis, and not, as one might suspect, a restriction.

It happens that the statistics of measurable quantities has received the most attention from mathematicians, notably Pearson, Lexis, and Charlier, and its development is correspondingly much in advance of the statistics of simple counting. The statistics of counting exists in germ, as in the familiar theory of drawing balls from a bag containing many balls of different colors, and in the statistics of birth-rates, death-rates, Mendelian ratios, etc., to which the bag-of-balls theory may be profitably applied.

When we count the correct and the incorrect responses made by any one person to the series of tasks constituting a test we

[1] Boring, E. G., *Amer. Journ. Psych.*, 31 (1920): 1.

are, metaphorically, determining the proportions of black and white balls in a sample taken from a bag containing a very large number. If the criterion of correctness or acceptability of response is properly chosen the ratio of acceptable to unacceptable will, within the limits of the sampling error, give the probability that further responses to similar tasks would be acceptable, provided the various responses are independent of each other as are the individual balls in the bag-of-balls mechanism. From a priori considerations we should not expect the different responses to be independent of each other, and a statistical theory which is valid for interdependent events must be of greater generality than that which suffices for the bag-of-balls experiment.

I shall attempt to indicate the lines along which such a generalized theory of counting may develop by discussion of a very simple example. Let us suppose that each of N persons has attempted two different tasks. In general there will then be four classes, as follows: those who succeeded in both tasks, n_{12} in number, those who succeeded in the first but failed in the second, ${}_2n_1$, those who failed in the first but succeeded in the second, ${}_1n_2$, and those who failed in both, ${}_{12}n$. Let the number of those failing in the first task, irrespective of success or failure in the second, be represented by ${}_1n$, and the number who succeeded, likewise irrespective of success or failure in the other, by n_1. And let analogous notation be used for the total number of successful and unsuccessful attempts to perform the second task. All these class frequencies may be conveniently arranged in a table thus:

${}_{12}n$	${}_2n_1$	${}_2n$
${}_1n_2$	n_{12}	n_2
${}_1n$	n_1	N

Within the limits of sampling errors, i.e., with the same degree of accuracy with which the sample represents the population, the ratio n_1/N gives the probability that a person taken at random from the population will succeed with task No. 1, and similarly the ratio n_2/N is the probability for task No. 2. If ability to succeed with No. 1 is independent of ability to succeed with No. 2, then the chance that a person taken at random will succeed

with both is $n_1 n_2 / N^2$, by the fundamental law of probability of compound events. But n_{12}/N is the actually observed probability. Let the quantity a_{12} be defined thus:

$$a_{12} = \frac{n_{12}}{N} - \frac{n_1 n_2}{N^2} \tag{1}$$

Then if $a_{12} = 0$, success in one task is independent of success in the other. If an individual succeeds in both it is purely fortuitous coincidence of successes. But if a_{12} differs significantly from zero we have an indication that some of the persons tested have had a common basis of response to the two tasks, or that the two tasks, though objectively different, have been in effect a single task and its repetition.

It is convenient, for reasons I will not attempt to give here, to define a *coefficient of association* thus:

$$A_{12} = \frac{N^2 a_{12}}{\sqrt{{}_1n n_1 \, {}_2n n_2}} \tag{2}$$

where A is the coefficient of association and the other symbols have the same meanings as above. This coefficient has a range of values from -1 to $+1$ and is analogous to the well-known correlation coefficient.

Let us consider a concrete example. The following sentences occurred, among others, in a "true-false" test of knowledge of rhetorical principles given to a group of University of Michigan freshmen:

(1) "Sitting in my warm cozy chair one afternoon, a fire engine dashed madly by on the outside, noisily clanging its gong."

(2) "While eating my supper last night, one of the calves got out and ran into the corn field."

The responses made by the individuals of an unselected fraction of the whole sample may be tabulated thus:

62 $({}_{12}n)$	74 $({}_1n_2)$	136 $({}_1n)$
65 $({}_2n_1)$	328 (n_{12})	393 (n_1)
127 $({}_2n)$	402 (n_2)	529 (N)

i.e., 62 persons thought both sentences were good, 74 thought the first sentence was good but the second bad, making a total of 136 who thought the first was good, etc.

For this table,

$$a_{12} = .05548$$
$$A_{12} = .297$$

The interpretation of the results in psychological terms is not easy. It is, of course, evident that the degree of association between successes in the two tasks is not high. The reason is not so evident. The two sentences are so much alike in form that it is difficult to understand how so many persons responded differently to them. It is difficult to avoid the supposition that many persons recognized the formal identity of the two sentences and therefore reacted to them identically. But of course response to the two tasks as formally identical does not imply "correctness" of response, for "correctness" means merely acceptability according to certain more or less arbitrary or conventional standards and it is conceivable that many people may form their language habits in situations where sentences of the type quoted above are acceptable, and therefore correct sentences. Such situations are, in general, extra-scholastic. Many other persons have developed other language habits in scholastic situations, or in others which give training of essentially the same kind.

One possible supposition, then, is that, owing to the psychological law of similar response to similar situations, there is an excess in the number of individuals responding similarly to both tasks, both correctly and incorrectly, over the number to be expected if responses are independent, and a corresponding deficiency in the number of individuals responding differently to the two tasks. Now $Na_{12} = 29.35$ is the amount of excess or defect in each compartment of the table. That is, if we subtract this number from the upper left and lower right cell frequencies and add it to the lower left and upper right, we obtain a table in which the combinations of successes and failures are purely random, but the proportions of success and failure in the tasks considered separately are the same as before. There are then only about 59 individuals who differ from bags of black and white balls, so far as these two tasks are concerned.

Again, we may suppose that some of the persons who responded acceptably to both tasks did so on the basis of knowledge of a

rhetorical principle which condemns all sentences of this form, while all the other individuals making up the sample responded at random, without knowledge of rhetorical principles, i.e., guessed. On this supposition, the number of persons responding on the basis of a common principle is given by the expression

$$\frac{Na_{12}}{a_{12} + \frac{{}_1n_2n}{N^2}} \tag{3}$$

This number turns out to be 250.37. This looks better, but there are still 279 persons who are equivalent to bags of black and white balls. Probably the correct interpretation of these results lies somewhere between the two extremes just pointed out. Further attempts to obtain the truth must involve analysis of the statistical association of the responses to these two tasks with those to other tasks, and also much further investigation of the thought processes. It is not easy to find much basis for confidence in the adequacy of tests made up of items of the type just examined, if the interdependence of responses is ignored.

If a person's responses to a series of questions are independent of each other, counting the numbers of correct and incorrect responses merely gives an index of the extent of that person's knowledge. If his correct responses are so distributed among the various questions that they exhibit an appreciable degree of interdependence we have an indication of either systematized knowledge or specialized knowledge. Finally, if we can choose a set of questions or tasks in such a manner that the effects of specialization are avoided, interdependence of responses indicates systematization only, and thus we have the possibility of a statistical definition of intelligence which is not incompatible with a psychological definition. Moreover, for the same reason the possibility of a statistical and practicable distinction between knowledge and intelligence also exists.

I will now deal briefly with the statistical treatment of the distribution of correct responses to a set of any number of tasks. Let m tasks be set for each of N persons, and suppose sufficient time is allowed for each individual to attempt all the tasks. Let n_1 be the number of individuals who succeed with task No.

1, and ${}_1n$ the number who fail, so that $n_1 + {}_1n = N$, n_2 and ${}_2n$ the corresponding numbers for task No. 2, etc. Then the mean score, i.e., the mean number of successes per individual, is obviously $(n_1 + n_2 + n_3 + \ldots\ldots\ldots + n_m)/N$. And the second moment of the frequency distribution of successes (μ_2) may be shown to be:

$$\mu_2 = \varphi_{11} + m(m-1)\alpha_2 \qquad (4)$$

where $\varphi_{11} = ({}_1nn_1 + {}_2nn_2 + \ldots\ldots\ldots\ldots + {}_mnn_m)/N^2$ and α_2 is the mean value of all of the possible values a_{12}, a_{13}, $\ldots\ldots\ldots$ a_{23}, $\ldots\ldots\ldots$ $a_{m,m-1}$ as defined in equation (1) on page 343. The quantity φ_{11} is thus the value that the second moment would have had if all the responses had been independent with the same proportions of success and failure for each task as those actually observed.

Further, it is interesting to consider the maximum value of the second moment in the case of complete association of all responses, so that all persons tested fall into one or the other of two classes, viz., those who succeed in all the tasks set, and those who fail in all. This maximum value is given by the equation:

$$\mu_2\ (max) = \frac{1}{N^2}\left[\sqrt{{}_1nn_1} + \sqrt{{}_2nn_2} + \ldots\ldots \sqrt{{}_mnn_m}\right]^2 \qquad (5)$$

I now propose, tentatively, that a useful *coefficient of coherence* be defined as the square root of the ratio of that part of the second moment which is due to the association of responses to the difference between the maximum and minimum values of the second moment, i.e., to that part of the maximum value of the second moment due to the complete association of all responses. This ratio is zero when all responses are mutually independent, and unity when all are completely associated.

$$S = \left[\frac{\mu_2 - \varphi_{11}}{1/N^2(\sqrt{{}_1nn_1} + \sqrt{{}_2nn_2} + \ldots + \sqrt{{}_mnn_m})^2 - \varphi_{11}}\right]^{\frac{1}{2}} \qquad (6)$$

Let us consider another numerical illustration. Three hundred and ninety-four unselected freshmen in the University of Michigan were given a "true-false" grammar test. Using only the first thirty items in this test, each of which was attempted by

every one of the three hundred and ninety-four persons, we obtain the following results:

$$\begin{aligned} \text{Mean} &= 21.74 \\ \mu_2 &= 13.2883 \\ \varphi_{11} &= 5.2509 \\ \alpha_2 &= .009238 \\ S &= .233 \end{aligned}$$

It is plain that the responses in this test are not highly associated, and therefore either the test does not emphasize organization of knowledge, or very little systematic knowledge existed in the persons tested. Which of these alternatives to adopt, or what compromise between them lies nearest the truth, it is impossible to say on the basis of the data available. Nor is it the purpose of this paper to attempt a solution of the problem, but rather to indicate some of the possibilities of a form of statistical theory which is by no means novel, but which has not yet been applied to many problems that have heretofore been bungled by an incompatible statistical theory. It seems probable that the question just left unanswered, along with many others, may be profitably attacked from the point of view herein stated.

Finally, the distribution of scores may be briefly discussed. The so-called "normal" curve still seems to dominate the thought of psychological statisticians, notwithstanding the numerous attempts by critical thinkers to dislodge the superstition. The theory outlined above furnishes additional argument against the common assumption that a "normal" distribution should be obtained by the use of a good test. As is well known to mathematicians, the second, third and fourth moments of a distribution must conform to certain conditions if it is to be regarded as "normal." These conditions are: (*a*) the third moment must be zero, and (*b*) the fourth moment must be three times the square of the second moment. Formulae for the third and fourth moments analogous to the one given above for the second have been obtained, and these moments have been shown to depend upon the proportions of success and failure for each task in the series comprised in the test, and upon the mean values of two other quantities defined as follows:

$$a_{ijk} = \frac{n_{ijk}}{N} - \frac{n_i n_j n_k}{N^3}, \qquad a_{hijk} = \frac{n_{hijk}}{N} - \frac{n_h n_i n_j n_k}{N^4}$$

These quantities also depend upon the interdependence of the different responses. Obviously then, the assumption of a "normal" distribution is equivalent to an assumption of certain proportions of successes and failures and certain degrees of interdependence, the latter being rigidly determined by the former, or vice versa. It is, however, not legitimate to make assumptions about quantities and relationships which are susceptible of direct computation. Moreover, a test does not measure intelligence, but elicits enumerable responses which may be regarded as manifestations in various degrees of intelligence. Responses, i.e., events, are not quantitative. Hence, to draw an analogy between variations of quantity and variations in combinations of events is to fall into confusion of thought. Not only is demonstration that intelligence is a quantitative attribute lacking, but evidence from experimental investigations that do not merely beg the question indicates a distinctly qualitative character. In any case the word is habitually used in the sense of *probability of intelligent thought or conduct.* The function of a test is to estimate this probability. Probability is without "dimensions" since it is a ratio of two enumerations.

In conclusion, then, it is apparent that Boring's solution of the dilemma of psychological statistics need not be accepted, with its disadvantages of discarding algebraically defined statistical constants. Instead, the substitution of the concept of enumerable, associated responses (events) for the concept of measurable quantity, and the substitution of the operations of the calculus of finite differences for the infinitesimal calculus provides the basis of an analytical method which is not only compatible with the data, but which also gives promise of a power to penetrate much further into the problems of interpretation than the methods in use hitherto.

University of Michigan

FACTORS CONDITIONING GROWTH

STUART A. COURTIS

IT IS well known that the exact definition of concepts in any field greatly facilitates the progress of science in that field. Thus, alchemy with its vaguely defined elements of fire, water, earth, and air was transformed to modern chemistry by the formulation of a definition of "element" which made possible the distinction between "element" and "compound," and led to the discovery of the laws of definite and multiple proportions.

In the field of education we are still handicapped by the vagueness of our concepts in regard to elementary factors. The time has come, however, when fundamental progress seems to be within the bounds of possibility. There are, of course, two fundamental problems here, i.e., the precise definition of the factor concepts and the determination of the laws governing their interrelationships. I am interested in both these problems, but I shall discuss only one of them. The purposes of this paper are: (1) to suggest modifications of existing definitions of the factors which condition growth; and (2) to direct attention to certain factors previously unnoticed.

Many years ago Galton recognized that there are two important factors in all growth and named them "nature" and "nurture." In a general way we have known for some time that nature refers to the quality of the growing organism itself, and we have come to ascribe such differences to the conditioning action of the forces of heredity. By differences in nature, we have said, we mean differences caused by differences in the germ plasm, and thus fixed and unalterable once the development of the individual has begun. The intelligence quotient (I. Q.) is such a nature factor and many a battle has raged about the problem of the "constancy of the I. Q." By nurture we have meant environmental influences acting to produce development.

The educationalist who has attempted the most precise definition of nature and nurture is T. L. Kelley.[1] Kelley writes: "Nature is defined as a trait, making for individual differences, which does not change with age. Nurture is defined as an influence, uncorrelated with nature, and making for individual differences, which changes with the length of time, or number of years through which it acts."

Such definitions contribute greatly to the clearness of our thinking because each points directly to but a single aspect of the growth situation and enables the investigator to identify these factors when he has found them. Thus, Kelley's definition of nature emphasizes two important characteristics: (1) that nature elements are qualities of the organism acted upon; (2) that nature elements are constant during the period in which nurture acts. Similarly, his definition of nurture emphasizes two characteristics: (1) nurture is an influence or force; (2) the action of such forces involves the passage of time. The longer the time the greater is the amount of nurture. Kelley's definition also calls attention to the fact that individual differences are the results of the interaction of nature and nurture.

Good as these definitions are, they seem to me incomplete. I wish to present evidence which suggests certain modifications as desirable. Before doing so, however, I desire to call attention to one implication of these definitions which appears to have escaped general notice.

Consider nurture, for example. The essential characteristic of nurture is that of an influence. It not only may act but also may change, in two important particulars, quality and intensity. If we call growth the effect produced by nurture acting on nature, what shall we call the effect produced by mere changes in the quality or the intensity of the nurture acting? I suggest that there is need to differentiate between the two situations. An illustration will make the situations plain (Fig. 16).

The figures for the total enrollment in Fisk University at Nashville, Tennessee, show the persistent upward trend which is characteristic of growth phenomena. Upon this general curve are

[1] Kelley, T. L., *The Influence of Nurture upon Native Differences*, 1926.

impressed many minor ups and downs which we, who are familiar with university conditions, know represent fluctuations in the nurture influences acting.

FIG. 16. Difference between growth and change

Fluctuations in total enrollment Fisk University

Fluctuations represent change; general trend represents growth. In this article the term "growth" will be used to describe the effects of constant nurture on constant nature, and the word "change" to describe mere fluctuations caused by changes in either nature or nurture during the growth period.

It is conceivable that similar variations might occur in the nature elements also. For purposes of scientific investigation and discovery of law, we need to differentiate between the complex situation in which nature factors and nurture factors fluctuate and the simple situation in which a constant nurture acts on a constant nature to produce a unitary type of effect.

I shall, therefore, use the word "change" in complex situations to describe variations in measured results, produced by fluctuations in nurture, and limit the connotations of the word "growth" to progress toward a defined maturity produced by a constant nurture acting on a constant nature.

The value of the distinction between change and growth lies in its implication for control. The attempt to measure growth in uncontrolled, complex situations results in data distorted by mere changes in the factors acting. For the precise evaluation of the effect of nature on nurture and for the determination of law, such data are well-nigh valueless. "Pure" growth data are essential. Such simplification and control of conditions are the inevitable outcome of precise definition. In other fields they have never failed to contribute greatly to progress.

The question immediately arises, Is it possible to secure growth data free from such distortion? The answer is yes, or no, according to one's point of view; no, if one insists on absolute perfection; yes, if one is content with progress toward perfection, retaining perfection as the ideal, and natural law as the relation which would obtain between factors if the ideal limit were ever attained.

For instance, many years ago, Boas investigated the eruption of teeth in boys. He presents data based on a study of boys of various ages, showing the percentage of the boys of each age-group who have cut the lower right canine tooth (Fig. 17).[2]

Here the maturity to be achieved by growth is precisely defined. Whether or not a particular boy has cut his lower right canine tooth may be unequivocally determined by careful definition and observation. The data, however, are not perfect since the children are not identical from year to year, and the nurture influences of food, sleep, activity, etc., are not controlled. The first defect could be overcome by taking a large group of boys and observing them continuously from the age of five, say, to twenty. The second defect, lack of control of nurture, would be more difficult to overcome and could never be made absolutely perfect. If, however, all the boys were inmates of an orphan asylum and care in control of diet and activities were exercised, the variation in the nurture factors could be very greatly reduced.

[2] In this and subsequent graphs, the curves drawn are smooth curves based upon the Gompertz formula (see later paragraphs). Actual observations are indicated by circles. Observations at variance with the smoothed results are believed by the author to be accounted for by variations in the purity of control of conditions of measurement.

However, in spite of minor irregularities caused by such lack of control of the conditions, the general character of the growth-curve under the definition is clearly revealed.

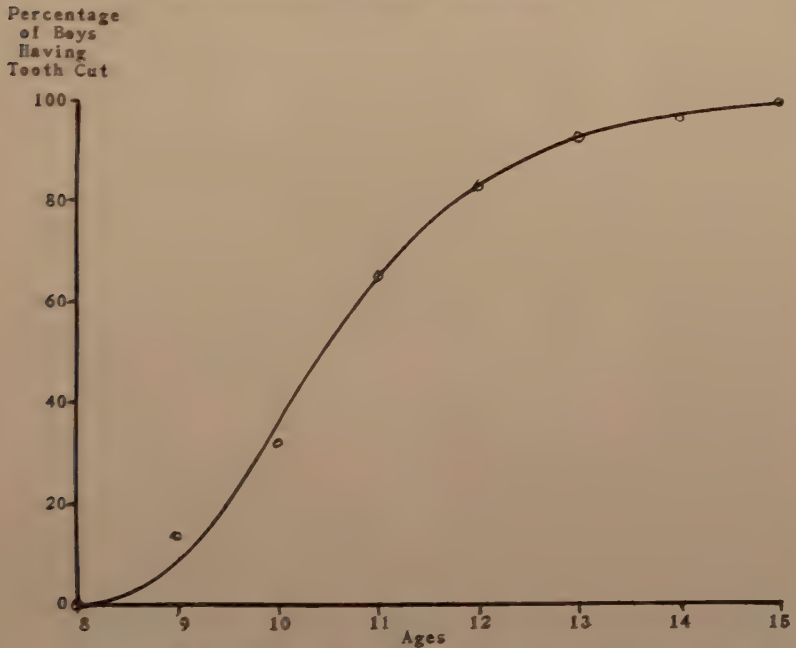

FIG. 17. Illustration of fairly "pure" growth or maturation curve

Cutting of lower right canine tooth in boys: from data by Boaz

The circles represent actual observations. For instance, at eight years 0 per cent of the boys had cut their lower right canine tooth; at nine years 13 per cent had cut this tooth; at ten years 32 per cent had cut this tooth, etc.

Many hundreds of such relatively "pure" curves occur in published growth data and are available for study. The auto-catalytic or S form is so characteristic that it has long been designated as "the" growth-curve, and many attempts have been made to explain it. Were there time, I could show you precisely similar curves for growth in physical, biological, physiological, psychological, educational, and social fields. All biologic growth in which there is progress toward a defined maturity produced

by constant nurture acting on constant nature has a period of rapid acceleration, a period of relatively constant progress, and a period of rapid retardation. Many are the theories that have been advanced to account for this characteristic form.

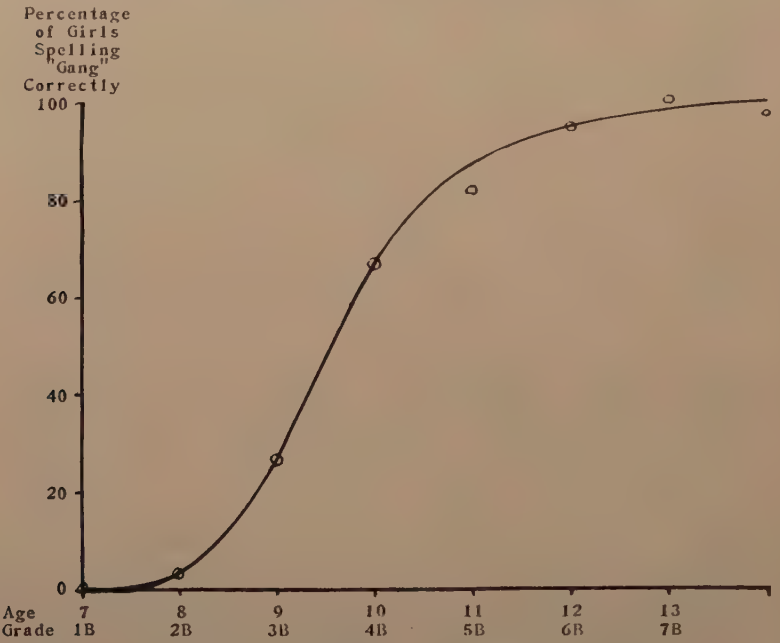

FIG. 18. Illustration of fairly "pure" educational growth curve

Maturation of ability to spell "gang" by girls in-grade-at-age: Data from a survey of Hamtramck schools

For instance, of the seven-year-old girls in the 1B grade 0 per cent were able to spell "gang" correctly; of the eight-year-old girls in the 2B grade, 3 per cent; of the nine-year-old girls in the 3B grade, 27 per cent; etc.

In education, as has been said, pure growth-curves are like those in other fields, indicating that educational development is a form of biologic growth. For instance, if the defined maturity is taken as the ability to spell the word "gang" correctly [3]

[3] The word does not occur in the course of study in spelling of the Hamtramck Public Schools. Accordingly the nurture influences will be assumed to be the constant opportunities offered by the environment for the incidental learning of the spelling.

and girls in-grade-at-age are selected as subjects to insure relative constancy of the nature elements from grade to grade, the percentage of the girls spelling the word correctly yields a growth-curve of the standard form (Fig. 18).

More than one hundred such curves for particular words are available, as well as curves for the development of other educational abilities.

In such situations, the children themselves constitute in a general way the nature elements. To define the concept more exactly, however, we need to isolate or describe nature more precisely. Children are not alike. Under such constant nurture as an hour's teaching they profit differently. By nature we mean those qualities in the children which *under constant nurture* cause them to react differently. How are such qualities to be identified and measured?

Fortunately in one field we have already achieved a partial definition and an approximate measurement. I shall try to make that definition and measurement more explicit. I refer to the field of intelligence. The mental age concept which we owe to Binet supplies a suggestion for such definition, and the I. Q. usually ascribed to Stern, but made practical for general use by Terman, supplies suggestions for measurement.

Burt gave the Binet tests throughout certain schools in London,[4] and published his data in full. Among the schools tested were several for mentally deficient children. Assuming nurture to be constant, a comparison of the growth data for normal and defective children reveals at once the effect of nature upon growth. For instance, consider the data for the test called "naming four coins" (Fig. 19).

The curves for both normal and defective children are of similar form, but the curve for the subnormals shows growth toward maturity at a slower rate of progress. On the one hand, note particularly that the defective children eventually achieve perfect control, and so far no evidence has appeared to suggest that any defined maturity would not be attained by subnormals if the training were continued long enough. On the other

[4] Burt, C., *Mental and Scholastic Tests*, 1922.

hand, the rate of progress for some of the higher forms of tests suggests that it would take several centuries of conventional nurture for these defectives to reach maturity. Evidently the placement of the growth-curve on the time axis and the rate of growth under constant nurture are measurable aspects of

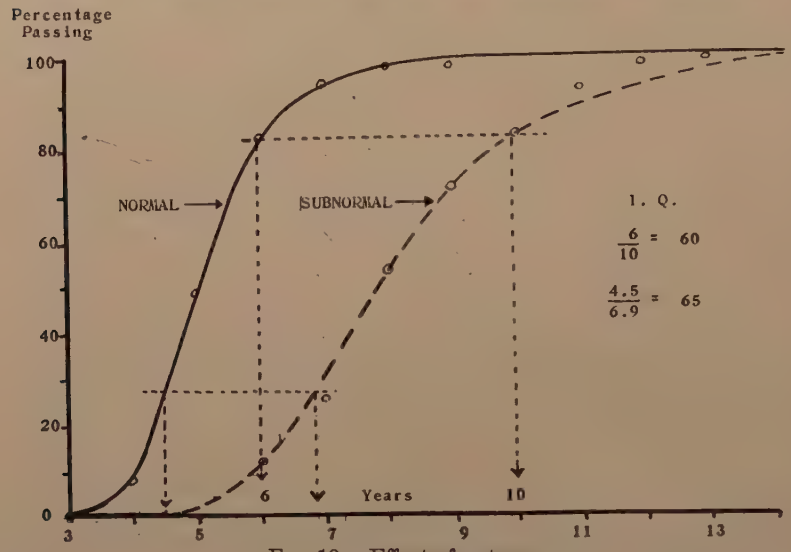

FIG. 19. Effect of nature

Comparison of growth-curves of normal and subnormal children in ability to "name four coins"

Solid line, normal children; broken line, subnormal. The horizontal line at 82 per cent passing cuts normal curve at six years of age and the subnormal curve at ten years of age. That is, the subnormals at ten years of age have the same achievement as normal children of six, therefore their I. Q. is 60. If the comparison is made at the 27 per cent level, the I. Q. is 65. The figure as a whole shows that the effect of nature is to displace the curve on the time axis and to change its slant.

the effects of differences in nature. From these considerations one can predict that the curve for superior nature will rise from the time axis sooner and progress at a more rapid rate. In all fields this has been found to be the case.

Just as the time characteristics of the curves afford a basis for a more exact definition of nature, so the time characteristics afford a basis for exact measurement of the quality of nature.

The defect of our present measure of nature, the I. Q., and the general outlines of an improved method will be presented.

At six years (6.0) of age, 82 per cent of the normal children are able to pass the test of naming four coins successfully. The test is accordingly designated as a test for a mental age of six. The children in the schools for the mentally deficient children do not attain this same level of development until the age of ten years (shown by the dotted horizontal line in Figure 19). That is, their mental age is six when their *time age* is ten, so that they may be said to have achieved sixty per cent of normal development (I. Q. = 60).[5] If, however, the comparison had been made at the level attained by normal children at the age of 4.5, the value of the I. Q. would have been .65. In general, the I. Q. tends to decrease with age and only approximates Kelley's criterion that nature is uncorrelated with age. The data presented and others like them suggest that a better measure is likely to be secured if it is based on the time aspects of the entire curve instead of on only one sectioning of it.

It may well be objected that there are too many uncontrolled conditions in the data presented to warrant such sweeping generalizations, and that is true. They are offered here as suggestions only. At another time and place,[6] mathematical analyses will be offered to justify these conclusions, but for present purposes it may help to clarify the situation to say that direct experimentation under controlled conditions has yielded analogous data.

For instance, the attempt was made to control nurture by constructing study-sheets in spelling in the use of which there would be no teaching other than the opportunity for practice afforded by the sheets themselves (Fig. 20).

At a given signal the children filled in as many of the blanks as they were able in the time allowed. There were all together twenty words difficult for fifth-grade children, and one minute

[5] In current practice, mental age is based not upon one test but upon a battery of tests for each age in order to increase the reliability of the determination. Moreover, the tests increase in difficulty from age to age.

[6] Before the 1928 meeting of the National Academy of Science.

was allowed for each word. The first day an initial test was given, followed by a study-sheet. The next day the test was repeated, then a second study period followed. This program was followed each day for five days, the final test, however, being given immediately after the study period.

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Study Lesson — Form 1

u-ni-ver-si-ty

....University.... is an important word to be able to spell. I find that there are five syllables in the word university as follows: ..u.. ..ni ver ..si.. ...ty..... I must remember that the second syllable is ..ni.... and that the word ...university..... ends with the letter ..y...

anx-ious

I am ...anxious to learn to spell the word .anxious. I notice that the first syllable is .anx.... and the second syllable is ..ious..... I also notice that the word is not spelled the way it sounds, so I must remember that the difficult part is ...x..... in the middle.

tal-ent

Any one with ...talent.... should know how to spell the word .....talent...y. It will be easy for me to remember

FIG. 20. A portion of one of the five self-instruction study-sheets used for the purpose of rendering constant the environmental influence producing growth in ability to spell

The study-sheets consist of four pages covering twenty words difficult for the fifth grade. The illustration shows a portion of one sheet after use. The girl has filled in the blanks.

It was found that the various study-sheets were only approximately equal in opportunities provided; also, that many children varied greatly in the effort put forth on different days. Certain children, however, responded uniformly and in such

cases we have progress toward a defined maturity (the correct spelling of the twenty words) made by different natures under (relatively) constant nurture. The differences in the curves of different individuals then reveal the effect of differences in nurture.

Thus, two boys both 128 months old and both in a certain 5A grade grew at very different rates (Fig. 21).

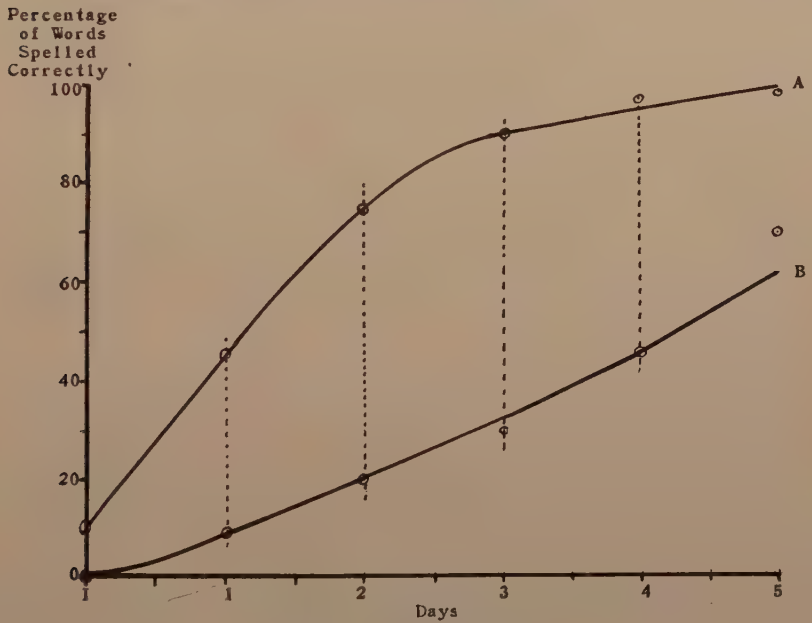

FIG. 21. Effect of nature

The defined maturity in this case is ability to spell a given twenty words correctly

The graph shows a record of two boys, 128 months old, in the 5A grade under conditions of constant nurture. Again the curves show that the effect of nature is to displace the curve with reference to the time axis and to change the slant.

They accordingly must be judged to possess different natures. The precise measurement of relative natures in this case involves some definition of zero points for the time scale, but the fact that under constant nurture the curves of growth of different individuals vary in their time characteristics is clearly established by such data.

Such data serve to define, also, another important problem. These curves are based upon the learning of a particular twenty words. Would the relative natures of the two boys be the same if determined by an easier or by a more difficult set of twenty words? Would the relative natures be the same for arithmetic as for spelling? Such questions cannot be answered at present. First there must be precise and reliable measurement of nature in terms of many and varied specific growths. Ultimately more general measurements of nature may be possible. For the present, therefore, I suggest that the definition of nature be taken as:

"Whenever constant nurture acts on different individuals, or groups of individuals, to produce growth toward a defined maturity, that quality of the organism acted upon which correlates perfectly with the observed differences in the time characteristics of the curves of growth will be called nature."

Under this definition measures of time placement and rate of growth become the raw material from which measures of nature may be derived by statistical analysis.

It may not be out of place to point out that the proposed definition differs from those previously proposed in that it defines the conditions of observation, then names an observable characteristic of growth data, while previous definitions have merely set up hypothetical characteristics to be searched for. It should be noticed, however, that the new definition includes Kelley's hypothetical characteristics, quality and constancy, and adds a third, time characteristics. It is believed the new definition will be more serviceable in making both analyses of growth data and precise measurements of nature and its effects.

The same technique will be used in the definition of nurture; it will be defined by its effect upon constant nature. That effect is manifested in the rate of development, the slant of the curve. The better the quality of training or the greater its intensity, the steeper the slant of the curve.

For instance, the consistent use of the study-sheets previously mentioned yielded the characteristic growth-curve. But

when the use of the sheets was interrupted and other forms of training substituted for them, changes in the slant of the curve occurred (Fig. 22).

In one experiment, the study-sheets were used on Monday and Tuesday in the standard way, establishing the general position

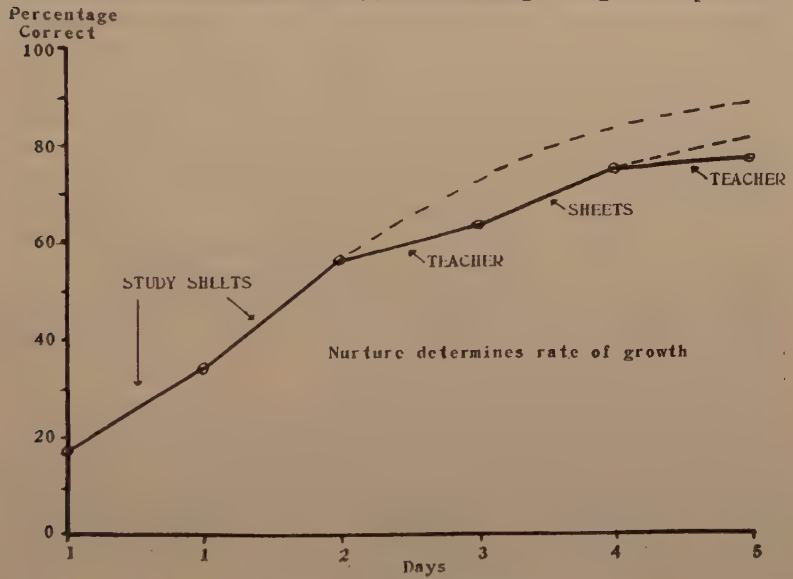

FIG. 22. Effect of nurture

In this experiment nature (children) and defined maturity (words to be spelled) were held constant while the training was varied

The curve is based on the scores of sixteen children in the 5A grade. Study-sheets were used on Monday and Tuesday with the results shown. Had the use of the sheets continued, it is known from similar experiments with other classes that the curve would have followed the first broken line. On Wednesday a student teacher was used to direct the children's study instead of the tests. The difference in slant between the solid line and the broken line indicates the effect of nurture. That is, nurture determines the rate of growth. The use of the sheets on Thursday and of a student teacher on Friday confirms this conclusion.

and slant of the growth-curve. On the basis of other experiments in which the sheets were used for five days, it is possible to predict that in this case the development would have followed the course indicated by the dotted line. But on Wednesday, instead of the sheets, a student judged to be the poorest among the graduating class at Detroit Teachers College in June, 1927, was asked to

teach the same twenty words and was given the same time (twenty minutes) in which to do it. The change in the slant of the curve indicates that her teaching did not produce as much learning as mere practice on the study-sheets would have done. To prove this point, the sheets were again used on Thursday. The fact that the resulting growth-curve parallels the probable original curve proves that the sheets have produced the same effect as at first.[7] On Friday, the best student teacher was substituted for the sheets, and while she did better than the poorer student, the divergence of the curve from the corresponding dotted curve indicates that her teaching ability also did not equal that of practice on the study-sheets. Similar experiments in large number prove that the slant of the growth-curve fluctuates in direct correspondence with known fluctuations in nurture. When nature is constant, therefore, nurture determines rate of growth.

Accordingly, I suggest that the definition of nurture be taken as:

"When growth takes place in groups or individuals of equal nature, under the influence of forces which are varied from individual to individual, those influences which are uncorrelated with nature but perfectly correlated with time and which affect the rate of growth will be called nurture."

This definition includes the essential elements of Kelley's, and adds an element which makes the identification and measurement of nurture readily possible.

One of the first fruits of the new definitions was a new and simple explanation of the growth-curve. The conventional explanation among biologists for the acceleration and retardation evident at the beginning and end of the growth period is the assumption of catalytic and inhibiting agents produced by the action of growth itself. No such agents have ever been isolated.

[7] It can be shown mathematically that the slant of the normal growth-curve throughout its entire length can be precisely expressed as a single constant value, in spite of the fact that the change in percentage correct varies at every portion of the curve. "Rate of growth" is to be taken to mean constant curvature. This is further explained in subsequent paragraphs.

A simpler explanation is as follows: Assume that the nature of a given growing organism is made up of a distribution of nature elements. (In a group of school children, each child would be one such element; in an individual, each cell might be such an element.) The elements would themselves be in different stages of development at the time nurture begins to act. Thus one child might have seen a given word like "gang," have written it, and have come to such a stage of development that one more single writing would serve to fix it in her memory. Another child might never

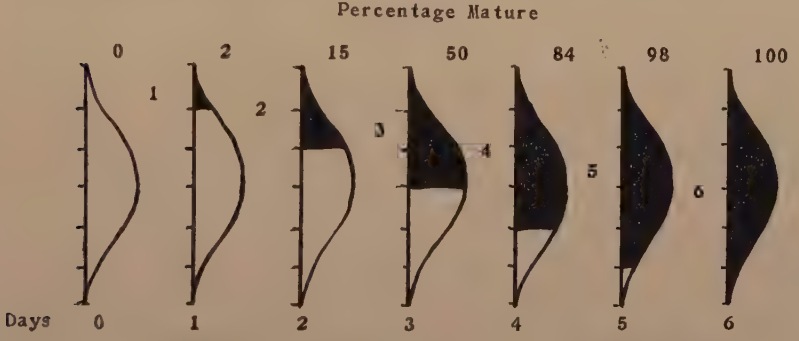

FIG. 23. Explanation of growth of a group under constant nurture

The diagram in the figure represents an assumed distribution of individual differences in nature. The base of the distribution is divided into equal units representing a linear scale of readiness to respond to nurture. Each day's training corresponds to one unit of nurture. The effect of nurture is considered to be constant as measured along the base line. The percentage of the group that is matured by the nurture is indicated by the shaded area corresponding to the advance made along the base. That is, with one unit of training 2 per cent of the individuals would be mature, with two units of training 15 per cent would be mature, etc.

have seen the word, might not know what it means, and might require many, many repetitions before she could be said to have learned it. That is, the nature elements will be in different stages of readiness to profit by nurture. Imagine a linear scale for "readiness to profit" and the nature elements distributed along it. Assume now that the effect of nurture is constant *as measured along the scale* for readiness. Suppose that each unit of nurture (day of training for spelling) completes the development of children in the first sigma of readiness. Then at the end of the first day, 2 per cent of the children would be mature (Fig. 23).

At the end of the second day, the children in the second sigma of readiness would also be mature, a total of 15 per cent mature, and so on. Then a constant rate of progress along the base line would yield variable percentages mature, and these variable percentages mature, when plotted, give the characteristic growth-curve.

The explanation can be given more simply by saying that growth-curves are types of ogives developed by nurture acting continuously through consecutive units of time (Fig. 24). If

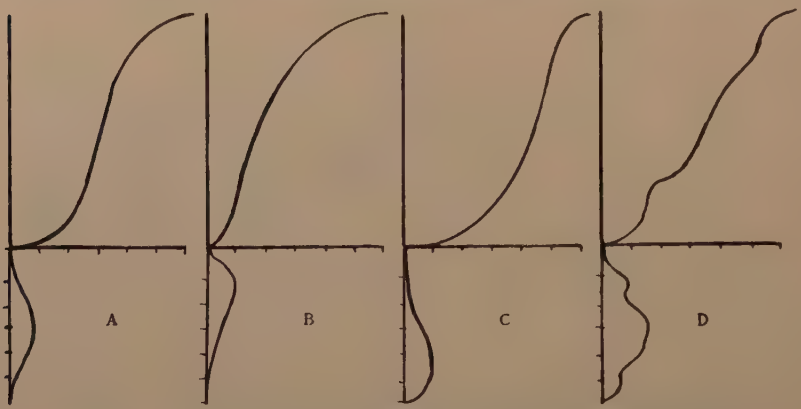

FIG. 24. The effect of form of distribution upon the growth-curve

Four distributions are shown and their resulting curves: *A*, normal, *B* and *C*, skewed, and *D*, irregular. The form of curve most frequently found in biological growth is very precisely represented by the Gompertz formula $y = n^{k^t}$.

the distribution is normal, the growth-curve will be symmetrical and of standard form (Curve A, Fig. 24). If the distribution is skewed, the resulting growth-curve will have corresponding type forms (Curves B and C, Fig. 24). If the distribution is irregular, the growth-curve will exhibit corresponding irregularities of form.

Clearly, then, the form of a growth-curve is conditioned by the form of the distribution of its nature elements. Most "pure" curves of the growth of individuals or groups toward a defined maturity produced by constant nurture acting on

constant nature are skewed curves, very precisely represented by a modification of the Gompertz formula[8]

$$y = kn^{r^t}$$

in which y = the percentage mature at time t,

k = a constant determined by the units in which maturity is expressed,

n = a measure of nature,

r = a measure of rate of development.

Notice that both n and r are constants. That is, that constant nurture acting on constant nature produces a constant effect.

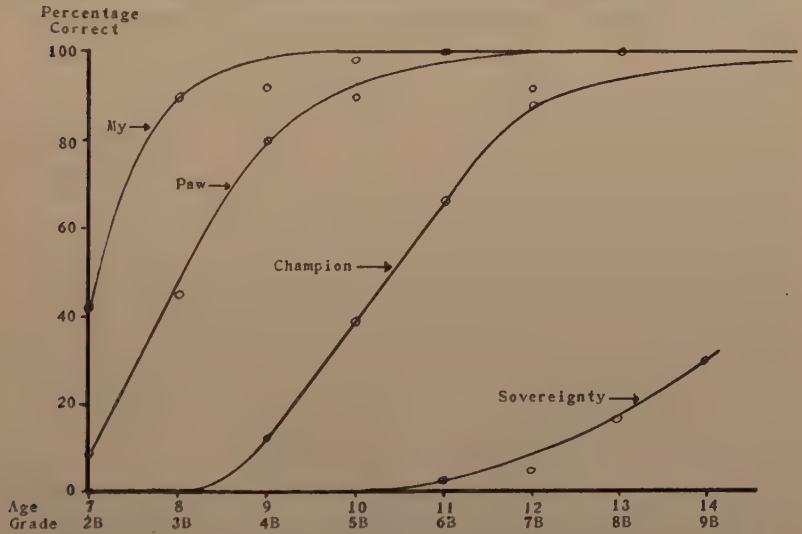

FIG. 25. Effect of complexity

Growth-curves for ability to spell the four words, "my," "paw," "champion," "sovereignty"

The children are identical throughout, therefore nature is constant. None of these words occur in the course of study, with the possible exception of "my." Therefore it is assumed that nurture is constant. The cause of the differences in the curves must be the differences in intrinsic difficulty of the words themselves. This intrinsic difficulty is called complexity. Based upon the scores of boys in grade at age.

Analysis of growth-curves with the precision called for by the proposed definitions has revealed another factor whose effect has hitherto been only partially recognized. If the growth-

[8] *Philosophical Proceedings of the Royal Society of London* (1825), Vol. 115.

curves of a constant group of children for a series of words in spelling are compared, it will be found that the time characteristics of the curves differ. Simple words mature early and the rate of growth is rapid; complex words mature late and the rate of growth is slow (Fig. 25). In other words, under conditions of constant nurture, nature and distribution, the *complexity* of the maturity toward which growth proceeds also conditions the growth.

The definition suggested for complexity is as follows:

"Whenever constant nurture acts on constant nature, under standard[9] conditions, to produce growth toward a defined maturity, that characteristic of a maturity which determines the time characteristics of the resulting growth-curve will be called its complexity."

Theoretically complexity is a thing-in-itself. That is, the relative complexity of two maturities is independent of the natures in which they are developed, of the nurture which produces the development, and of the form of the distribution of nature elements. That is, the word "sovereignty" ought to be a given number of times more complex than the word "champion," whether the determination of relative complexity is made by means of normal children or subnormal, whether by five minutes' training a day or by ten minutes' training. Such changes in nature and nurture would, of course, radically modify the form of the resulting curves, but not the relative complexities of the two words. Practically, our present measurements are too imperfect to establish this hypothesis with certainty, but data which strongly suggest it are not wanting.

Nurture and complexity together determine rate of growth. That is, in the formula previously mentioned, r is some function of complexity (c) and nurture (e). The most probable relationship is expressed by the formula

$$r = \frac{c}{e}$$

[9] The term "standard" is used to indicate that the distribution of nature elements must also be constant from group to group.

in which r = the rate of growth, c = the complexity, and e = the nurture or environmental influences.

The real problem in the study of growth-curves is the establishment of all definitions and hypotheses on the basis of exact measurement, and the scientific determination of relationship between factors. This work is well under way and the results are most encouraging. It may not be out of place to call attention to the fact that as soon as the validity of the foregoing definitions, assumptions, and hypotheses is established, it will be possible to construct a series of scales and units for the precise measurement of growth phenomena under conditions comparable with measurements in other fields. For the present, the chief value of the proposed definitions is that they make possible experimentation under the law of the single variable, experimentation which alone can establish their truth or falsity.

By way of summary, may I repeat the suggestion that the term "growth" be limited to phenomena which occur when progress toward a defined maturity is produced by constant influences acting uniformly through consecutive units of time upon an organism of constant membership and quality, composed of a standard distribution of nature elements?

The factors conditioning such growth have been shown to be:

1. Nature, or the quality of the organism acted upon;
2. Nurture, or the quality of the influences acting;
3. Complexity, or the quality of the maturity being developed;
4. Variability, or the form of the distribution of nature elements.

The effects by which all of these factors may be identified and measured are the forms of the curves and their time characteristics — placement and rate of growth. Taken as a whole, the definitions offer new avenues of attack upon the study of growth phenomena and new possibilities in measurement and experimentation.

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SOME STUDIES IN BODY SWAY

GLORYN C. EICHKERN AND ERNEST B. SKAGGS

THIS paper gives a report of the technique used and the results obtained in several studies of "body sway." As any individual stands erect his body moves about to some degree and in various directions. The term "body sway" refers to those movements which take the body away from its center of balance as one stands erect. No one can stand perfectly still for any length of time.

APPARATUS AND PROCEDURE

The apparatus consisted of an overhead-piece, a detachable platform, and a body-piece. In the diagram (Fig. 26) the various parts of it are shown. The legend accompanying the diagram should make clear the nature of the apparatus and its use. For want of a better name the device has been called a "swaygraph."

After the body-piece was fastened to the subject's back, he was asked to stand under the overhead-piece, which was so adjusted that the writing pointer, *I*, would rest properly upon the smoked paper on the platform *J*. The subject's heels were one and five-eighths inches apart and it was permissible to place the feet at any angle not exceeding twenty degrees. This allowed all our subjects to use their natural foot-position. We did not encounter any individual who desired to have both feet on a straight line, or turned outward at an angle of more than twenty degrees. Each subject stood three and one-half feet away from a wall which was painted a light oak color. Three circular black spots, three fourths of an inch in diameter, were placed on the wall directly in front and served as fixation points in those tests during which the eyes were open. These spots were placed one above the other, being 58, 62, and 67 inches above the floor.

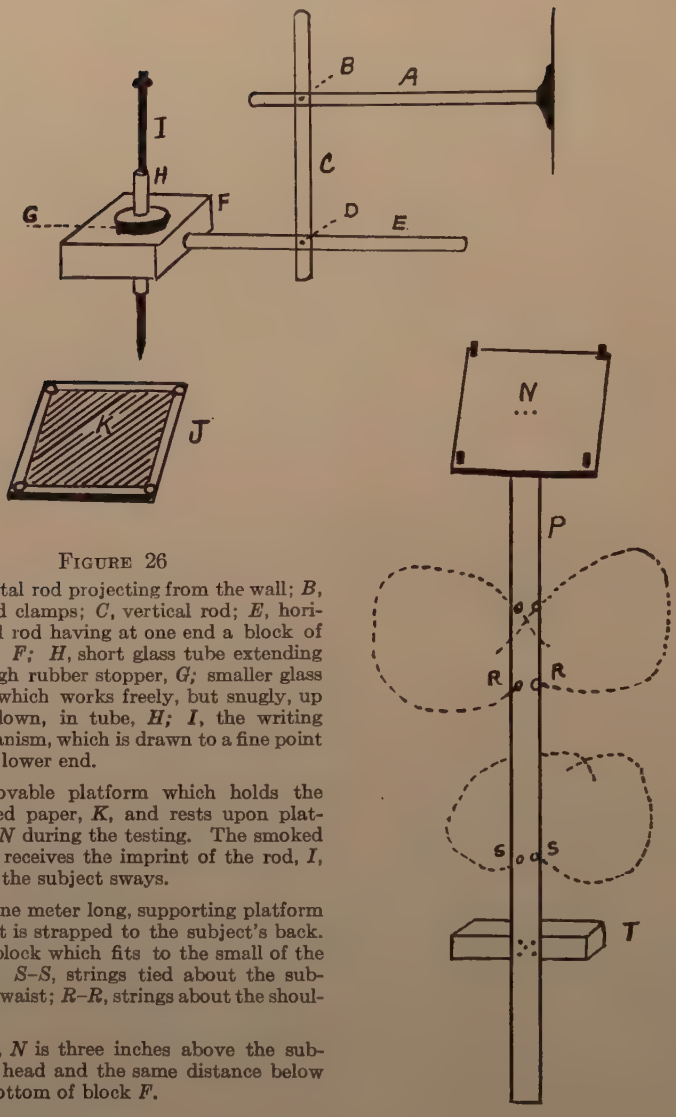


FIGURE 26

A, horizontal rod projecting from the wall; *B*, *D*, rod clamps; *C*, vertical rod; *E*, horizontal rod having at one end a block of wood, *F*; *H*, short glass tube extending through rubber stopper, *G*; smaller glass tube which works freely, but snugly, up and down, in tube, *H*; *I*, the writing mechanism, which is drawn to a fine point at its lower end.

J, a removable platform which holds the smoked paper, *K*, and rests upon platform *N* during the testing. The smoked paper receives the imprint of the rod, *I*, when the subject sways.

P, a rod, one meter long, supporting platform *N*. It is strapped to the subject's back. *T*, a block which fits to the small of the back. *S–S*, strings tied about the subject's waist; *R–R*, strings about the shoulders.

In testing, *N* is three inches above the subject's head and the same distance below the bottom of block *F*.

Each person selected the spot which was most nearly on a level with his eyes.

After the subject had been warned to "strike his balance" the experimenter lowered the marking pointer and, as soon as the subject signified that he was balanced, the marker was permitted to rest upon the smoked paper, thus beginning the record. It is just here that one meets the most serious possible source of error in our work. It is obvious that we wish to start the record only when the subject is "well balanced," that is to say, when he is in such a position that the upper part of his body is on a vertical line running through his center of gravity. It is quite possible and probable that the "starting point" on the record frequently does not represent the true "center of balance." We tried to reduce this source of error by warning the subject to prepare himself and state when he was balanced. Also we have relied upon several records, with the hope that this variable source of error would be neutralized.

Each test reported in this paper lasted for one minute. This time was selected after a little preliminary probing. It was found to be long enough to make strong demands upon the subject's ability voluntarily to control his movements and short enough to avoid fatigue and unpleasant strain. The subjects consisted of students from the senior writer's classes in psychology and the two writers themselves, who are listed as G. C. E. and E. B. S. One other person, E. E. P., served as subject in one study which involved an intensive practice period. The last three persons will be referred to as "trained subjects."

TREATMENT OF THE SMOKED PAPER RECORDS

The record of the body sway was left in the form of a continuous mark upon the smoked paper. When the subject swayed forward, the pointer recorded a mark in the backward direction and vice versa. At the end of the test the records were properly oriented. One pointer of a pair of dividers was placed upon the starting spot on the smoked paper record. The other pointer was then placed upon the point farthest removed from the starting point and this distance was used as a measure of the amount

of sway. This distance really tells us only how far the subject deviated from the starting point on the record. Another worthwhile measure, and perhaps a more valuable one, would be that of the total distance covered by the subject in his sway. We had, however, no means of measuring the actual distance covered by the recording pointer. It is quite possible for a subject to have a small sway score, according to our manner of computation, and yet have a record which shows far more actual movement than does another record where the sway score is much greater.

By examining the records one can note the direction of the sway and any other characteristics which may be obvious to the eye. In all investigations an introspective report was secured and this was used both as a check upon the records and as additional information about the sway processes.

PROBLEMS INVESTIGATED AND RESULTS OBTAINED

1. *The variability of the subject on the sway test.* It was fairly easy to control external conditions but, of course, impossible to keep the internal conditions of the subject constant. Thirty-seven untrained subjects were given the sway test, which was repeated one month later. On each occasion one record was taken with the eyes closed and one with the eyes open. The following correlations were found between the individual scores made in the two tests:

Series with eyes open, r was $0.43 \pm .087$
Series with eyes closed, r was $0.51 \pm .080$

On the average the subjects tend to keep their same relative rankings on two different tests, although individual exceptions were found.

We have found that the individual is quite variable on the sway test from day to day. A study of Tables II and III shows that the three trained subjects gave a variable performance even when judged by their weekly averages.

2. *Practice effects.* If one compares the averages for an untrained group of subjects, one finds a consistent practice effect.

Table I gives the averages for a group of forty untrained subjects who took the test a first and a second time, the second test being taken one month later.

TABLE I

	First Test Series		Second Test Series	
	Eyes open	Eyes closed	Eyes open	Eyes closed
Mean.....	29.6	41.1	27.7	39.7
M.V.....	8.6	14.5	9.0	10.6

Tables II and III give the weekly averages for the three trained subjects. They took the sway test four days a week for a period of six weeks during the summer of 1927. Subject E. E. P., in Table II, alone shows a marked practice effect, but it will be noted that there is no further improvement in the capacity involved after the first week. In Table II, subject E. E. P. likewise shows some improvement with continued practice. With the eyes open (see Table I), E. B. S. and G. C. E. show no practice effects, at least none that were clear-cut. With the eyes closed, E. B. S. shows a practice effect whereas G. C. E. displays little, if any, improvement due to practice.

TABLE II

Weekly Averages: Eyes Open

Subject	1st week	2d week	3d week	4th week	5th week	6th week
E. B. S.	20.8	22.4	24.4	23.0	21.3	32.0
E. E. P.	41.2	25.9	33.5	27.1	27.0	28.5
G. C. E.	20.3	20.8	22.5	21.8	26.7	19.6

TABLE III

Weekly Averages: Eyes Closed

Subject	1st week	2d week	3d week	4th week	5th week	6th week
E. B. S.	30.4	29.3	26.0	25.5	27.3	25.8
E. E. P.	46.8	39.6	38.6	46.5	26.5	31.3
G. C. E.	25.8	35.3	31.0	39.0	41.3	24.8

We believe that our data justify us in concluding that: (1) with untrained subjects there will always be found a small improvement due to practice; (2) the maximum of ability is reached after a very few practice trials and thereafter there is little or no improvement; and (3) practice effects are more pronounced with eyes closed than with eyes open.

3. *Comparison of results obtained with eyes open and eyes closed.* Theoretically one would expect to find less sway when the eyes are open than when they are closed. A study of the first three tables or the last two will show that, on the average, the subject sways less with the eyes open. We have found a few individual exceptions; some individuals do equally well under either condition and some actually do better with eyes closed.

4. *Sex differences.* In two separate investigations of untrained subjects conflicting results were obtained. On the basis of these results we can say only that our data suggest that there are no noticeable sex differences. This point, however, needs further study.

5. *Relation between sway and height.* The correlation between sway (with eyes open) and height was computed for fifty-one subjects, r being $-0.513 \pm .069$. Inasmuch as a decrease in the size of the sway score means an increase in efficiency, the negative correlation indicates that taller individuals sway less than shorter ones. That is to say, there is a positive correlation between efficiency in the sway test and height.

The correlation between sway (with eyes closed) and height was found to be $0.076 \pm .0938$. As there were only thirty-two subjects involved in this comparison and inasmuch as the probable

error is so large, one can scarcely make any positive statements. The tentative suggestion is that there is no correlation between sway (with the eyes closed) and height.

As other factors may work to bring about the relationships expressed above (such as weight), further work should be done along this line, and the method of partial correlations should be used. At best our data can be considered only as suggestive.

6. *Relation between sway and hand-arm steadiness.* Using a Whipple steadiness tester and taking the average number of "touches" for three trials,[1] we calculated the correlation between steadiness in this test and general body steadiness as shown in the sway test. For this comparison the condition of eyes open in the sway test was used, the number of subjects being thirty-two. The correlation between these two tests was found to be $-0.002 \pm .096$, or, we may say, zero.

7. *Relation between sway and attention.* Does one sway more when trying to keep balanced with attention on this effort or when attention is concerned with other matters? We have used and compared two conditions, one of which may be called "attention on sway" and the other "attention on problems." For the sake of brevity we will refer to these hereafter as A S and A P conditions respectively.

Under the A S condition the subject was instructed to fix his attention upon the task in hand, namely, that of keeping well balanced. He was to assume the attitude of desiring to stand without moving and to keep his attention on the various sensory reports which were constantly present. If his sensory cues told him consciously that he was off his balance, he was to correct the fault at once.

In the A P condition the subject was instructed to work mental multiplication problems and, as far as possible, to forget that he was taking a sway test. Two two-place numbers were given him to multiply and he worked each problem as quickly as pos-

[1] The same method of giving and scoring the steadiness test was used in this experiment as in the work reported by Skaggs in the *Journal of Comparative Psychology*, VI (1926), 303–315, entitled, "Changes in Pulse, Breathing, and Steadiness in Startledness and Excited Expectancy."

sible, reporting the answer. None of the two-place numbers was larger than 20 and, in case a subject found a problem too difficult or emotion-producing, he was given an easier one. We wished to keep an active but distracted condition of attention.

Tables IV and V give the results for the trained and untrained subjects respectively. Each average given in Table IV is based upon sixteen separate records. Each subject's average given in Table V is based upon three separate records. All figures in parentheses are mean variations.

TABLE IV

Comparison of the Averages of Trained Subjects with Attention on Sway and on Problems

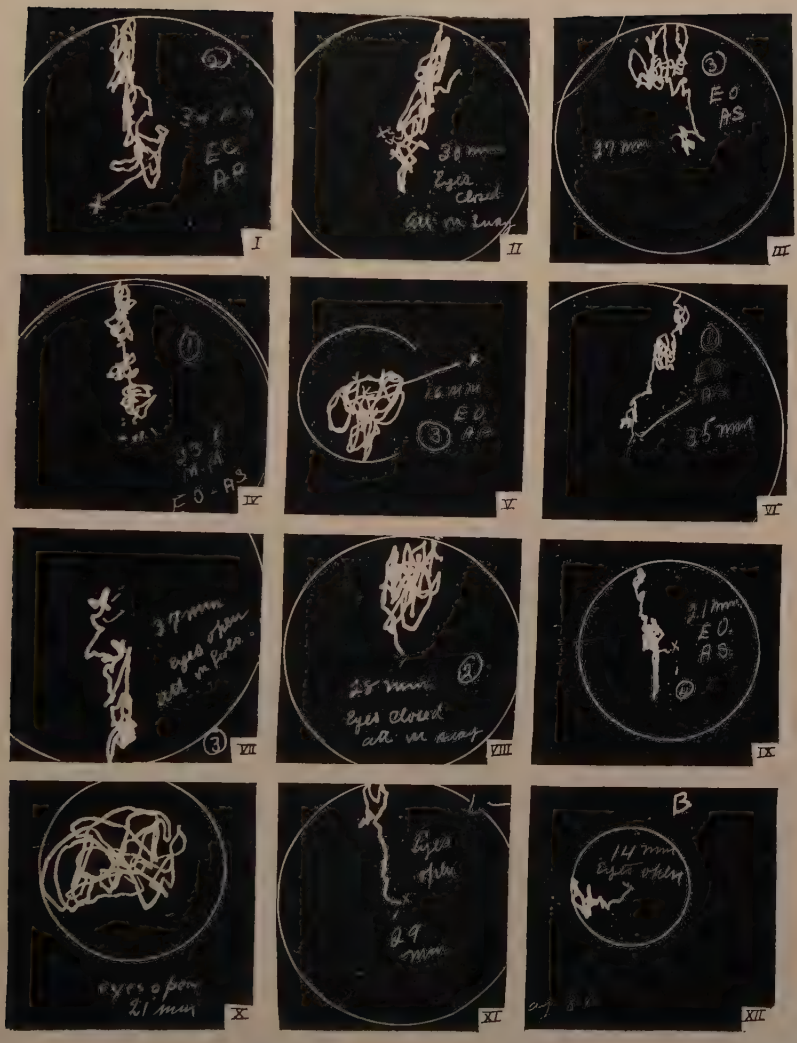
Subject	Eyes Open		Eyes Closed	
	A S	A P	A S	A P
G. C. E.	15.3 (3.2)	24.3 (5.7)	25.5 (9.1)	28.0 (7.1)
E. B. S.	27.4 (5.0)	24.4 (4.9)	26.7 (5.6)	23.9 (5.3)

TABLE V

Comparison of the Averages for Ten Untrained Subjects with Attention on Sway and on Problems

Eyes Open		Eyes Closed	
A S	A P	A S	A P
32.7	38.7	37.7	49.3
20.0	18.7	28.0	23.2
24.7	21.3	27.2	28.5
20.5	20.5	38.5	23.0
29.7	32.2	34.5	34.7
25.3	22.3	22.2	42.0
22.5	27.3	20.5	22.0
27.7	20.0	33.3	19.0
28.0	16.0	15.0	20.3
25.2	19.7	22.3	21.0
Mean 25.6	23.7	27.9	28.3
M. V. 3.11	3.55	6.48	8.26

PLATE XXII



Twelve records taken by means of the swaygraph. The front, the back, and the right and left sides of the subject are represented by the top, the bottom, and the right and left sides of the plate, respectively. Most of the types of sway are represented in these twelve samples

The results in the case of the two trained subjects (Table IV) are diametrically opposed. As each was tested quite thoroughly the data suggest that some persons will do better under the A S condition and some better under the A P condition.

The averages for the untrained subjects indicate a slightly better performance in the A P condition. If, instead of comparing averages, we note the individual cases, we find that, with eyes open, six subjects out of ten have better records with attention on problems. In the eyes closed condition we note that six out of ten persons do better with attention on the sway. All in all, our data for the untrained subjects appear to carry out the suggestion made above, namely, that some do better in one condition and some better in the other, with a tendency to do better with attention distracted from the sway process. This has been a distinct surprise to the writers, who expected a much better performance when attention was on the sway process. Evidently the body is provided with a reflex or automatic mechanism whereby the body balance is regulated without attention to the process.

8. *Direction of sway.* It is difficult to classify our various records in regard to direction of sway. Plate XXII presents most of the types. In general, it may be said that most individuals sway in a front-back direction and relatively few sway to the right or left. We have no record of any individual who swayed directly to the right or left. There is no difference in the direction of the sway with eyes open and eyes closed. If an individual tends to sway forward with eyes open he tends likewise to sway forward with eyes closed. Figures V, VIII and X (Pl. XXII) are samples of rotary motions. This form of motion is found less frequently in our investigations than such records as Figures I–IV. Most subjects keep moving forward whereas only a few move backward.

9. *Introspective reports, with special reference to the nature and location of the sensory cues used in balancing.* Introspective reports were taken at the end of each record. Of the forty untrained subjects thirty-three reported that, when their eyes were closed, their kinesthetic or muscular sensations were far more conscious than when their eyes were open. The trained subjects all reported this condition. Closing the eyes takes away the visual distractions

and throws one back upon the muscular tensions and touch sensations.

The majority of subjects knew whether they were making a good or a bad record, although a few badly over- or underestimated their actual record.

Most of the sensory cues were located in the large leg muscles and in the muscles about the waist. Shiftings of pressure tensions on the feet were often reported. Thus, subject G. C. E. reports that "there was a tension in the leg muscles about my right knee, changing later to the left hip. Muscle movements were also noticeable in the small of my back and in the feet." E. B. S. reports: "Felt movement in the region of the waist and lower trunk. Then felt a pronounced shifting of tensions from the left to the right foot (pressure). Felt several spasmodic jerks in the muscles of my back." These are merely samples of many such reports. Out of a study of these reports we conclude that the subject is aware of his shift "off balance" by the change in muscle tensions and touch sensations which come from all parts of the body.

Very little mention was made in the introspective reports of head movements. This was likewise true of eye movements. If there were any noticeable eye movements they were very rare. Likewise, few subjects reported any change in the visual field when the eyes were open. With a small body sway there would not be a very large displacement of the visual field. Our quantitative records indicate that the visual cues were important, but they were completely overshadowed by the kinesthetic and touch sensations. The trained subjects occasionally reported some little displacement of the visual field. Thus E. E. P. reports: "With eyes open I perceived most of my sway by sensations (objects) on my left moving to my right."

None of our subjects reported any peculiar or unique sensations which were to be located about the ears. In spite of the fact that they were often asked to look for "static sensations," none was ever reported. That the receptors in the semi-circular canals are important in regulating body balance is usually accepted as established, but we in our experiments have found no evidence that they furnish any "sensations."

CONCLUSIONS

We may briefly summarize the main findings and suggestions of our studies in body sway:

1. The correlation between test results taken on two different occasions was found to be 0.43 and 0.51, a fair positive correlation.

2. The subject shows considerable variation in his ability to stand erect, as measured from day to day.

3. With untrained subjects a small practice effect is found. With systematic training it is found that practice effects are soon ended. The subject quickly reaches his maximum ability.

4. On an average the subject does better in the sway test with eyes open than with eyes closed. There are some individual exceptions.

5. No clear-cut sex differences were found in our work; our data are conflicting on this matter.

6. Our data indicate that shorter persons sway more than taller ones.

7. No correlation was found between ability to hold the body steadily erect and ability to control the steadiness of the hand-arm muscles.

8. Some individuals do better with attention on the sway, whereas others do better with attention on other matters. Our subjects are about evenly divided in this respect.

9. Introspections indicate that kinesthetic sensory cues are the most noticeable conscious content during the sway test.

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THE INFLUENCE OF MARITAL STATUS ON LABOR TURNOVER*

ADELBERT FORD

THE greatest general problem confronting the man interested in the psychology of efficient labor management today is the difficulty of securing adequate and accurate measurements of employee efficiency on the job. Without a measurement of employee efficiency we have no good means of ascertaining the validity of selection methods, no way of determining the seriousness of environmental conditions on the labor force, and no check concerning the adequacy of methods of labor management. The skilled production job offers less trouble in making efficiency studies because mechanical methods of measuring output are possible. But in the broad class of non-production jobs, probably more numerous than any other kind, we find trade traditions and individual opinion supplanting the use of exact measurements.

Several criteria are possible as means of ascertaining a degree of employee efficiency on non-production jobs, but no one means may be accurate. The monthly percentage of labor turnover may be regarded as a partial measure of the general condition of efficiency in a plant where work is complex and the learning curve covers a long period of time. This is especially true where the voluntary resignations of the employees are considered apart from the enforced discharges for incompetency. The customary evil effects of a too high voluntary turnover may be listed as follows: (1) too great a percentage of slow and untrained men; (2) increase in the overhead cost of hiring men; (3) excessive amount of time spent in teaching new men; (4) waste of materials in the

* We are indebted to Mr. A. K. Hurlburt, employment manager, and Mr. Sam Fraser, of the Substations Department of the Detroit Edison Company, for assistance and coöperation in securing the data for this paper.

hands of incompetent beginners; (5) higher probability of accidents with unskilled labor; (6) breakage of machinery.

In the present report we deal with a homogeneous group in the task of operating electrical substation machinery. Rotary converters for changing alternating current to direct current must be started and stopped. Alternating current lines must be phased and coupled by switches. Current strength is adjusted to meet the fluctuating demands of consumers. The instruments are complex and the work exceedingly variable. Mistakes carry heavy penalties in the possibility of both injury to life and the destruction of valuable equipment. Absolute precision is at a premium, while speed of production is seldom desirable.

In this work the promotion rate is not rapid enough to entice many men with higher education, such as electrical engineers, and while it is very desirable to have intelligent employees, it is certain that nothing can supplant the presence in an operator of a large system of very precise and thoroughly automatized skill habits, abilities which cannot be learned in any technical school, and which can be obtained only through a thorough training on the job. Such measurements as we have made indicate that the average substation operator does not reach maximum efficiency until he has been two years in the work, and any condition of labor turnover which reduces the number of men with more than two years of experience cannot help but throw the control of substation work into the hands of men with relatively undeveloped skill habits. It becomes important that the employment department so select men that there will be as small a percentage of voluntary turnover as possible. We set about to find a means of estimating the probability of length of service at the time the man is hired. We shall try to answer the problem concerning the causes of the quitting tendency of otherwise very competent employees by presenting two out of several suggestions — *age* and *the degree of family responsibility.*

Marital status and age have been made the basis of determinants of job efficiency in other occupations. Miss Goldsmith [1]

[1] D. B. Goldsmith, *A Study of Five Hundred Personal History Blanks*, The Guardian Life Insurance Company, 1922.

studied the effect of age and family responsibility on the efficiency of salesmen for life insurance. She found an optimum age qualification between 23 and 24 years, and distinctly favorable results from married men. Similar results were obtained through the work of the Bureau of Personnel Research [2] on other groups of salesmen. There is some probability that the effects of age and family responsibility are factors to be watched also in studying turnover in all occupations. It was for this reason that we made the probability measurements for men in the occupation of substation operation.

With regard to the importance of marital status, we may consider some of the reasons for possible results from the possession of a family. In our present method of paying wages to employees, little or no allowance is made for the fact that a man must support a family. The adequacy of the salary in meeting the household expenses may become an incentive for an employee to keep his job and avoid a period of unemployment. It may mean that small troubles and dissatisfactions on the job are not as likely to become the excuse for quitting when there is a penalty of family suffering to be considered. An income of $40 per week may be more than sufficient to supply the needs of a single man, but no more than barely sufficient to keep a family man from friction with the bill collector. The presence of a family may become, therefore, an important incentive for steadiness on the job.

It seems probable, also, that there may be a change in the attitudes of young men toward occupations as they get older, apart from the fact of assuming family responsibility. Traditionally, young men in the early twenties might be expected to go through a process of trial and error in job selection, hunting for work which is most agreeable, remunerative, or promises the greatest degree of future promotion. Having survived a period of struggle for job adaptation, the intelligent young man may be expected finally to have made his choice and to begin to settle down into some occupation which gradually impresses into his nervous system a group of specialized habits tending to cement him closer and closer to a single line of activity. We may now

[2] *Service Bulletin, Bureau of Personnel Research*, January, 1923.

refer to the class as the domesticated *genus homo*. It might seem that the probability of finding the so-called "drifters" is higher among the younger age groups than among the older. While a result showing greater stability of older men would tend to prove that they are better adapted to substation operation, we must also be on our guard against the possibility that with increasing age we are losing a desirable plasticity to training effects, and that employees who are too old may introduce human hazards more serious than high turnover rate.

We must also be on our guard lest the supposed effects of family responsibility be mistaken for the effects of age on the incentives of employees. It is perfectly possible that the family men are more steady on the job, not because they are supporting families, but because they are older. Whatever method is used for demonstrating the importance of marital status, it is to be checked against the effect of age grouping without marital status being involved.

In the department of substation operation we tabulated records for 319 employees who started with no experience and were put through a relatively homogeneous kind of training for the job. The application questionnaires of these employees indicated age and marital status among other things. Our object was to determine the probability that marital status and age might be determining factors for voluntary turnover as against enforced turnover. Of these men, 224 were single at the time of hiring, and 95 were married. It was not possible to divide the married men into groups with various sizes of families because such a division would have promoted evidence based on too few cases. We did, however, mark the effect of age tendencies of married men apart from the age tendencies of single men, in order to determine the separate effects of the two factors.

In the first graph (Fig. 27) we have plotted the average length of service against the age of the entire group, married and single men together. The shape of this curve indicates that the group from 20 to 24 years of age represents the worst possible one for voluntary turnover, the very classification which Miss Goldsmith found the best for selling life-insurance. The 15–19 group is

better, but still not enough better to be worth great consideration. The difference between men in their late 'teens and men in their early twenties may possibly be due to the steadying influence of parents in the former age group. Beyond the 20–24 group there is a conspicuous increase in the steadiness of employees. (The ages given are the ones stated on the application questionnaires.) The 30–34 group proves to have the highest tendency to stay

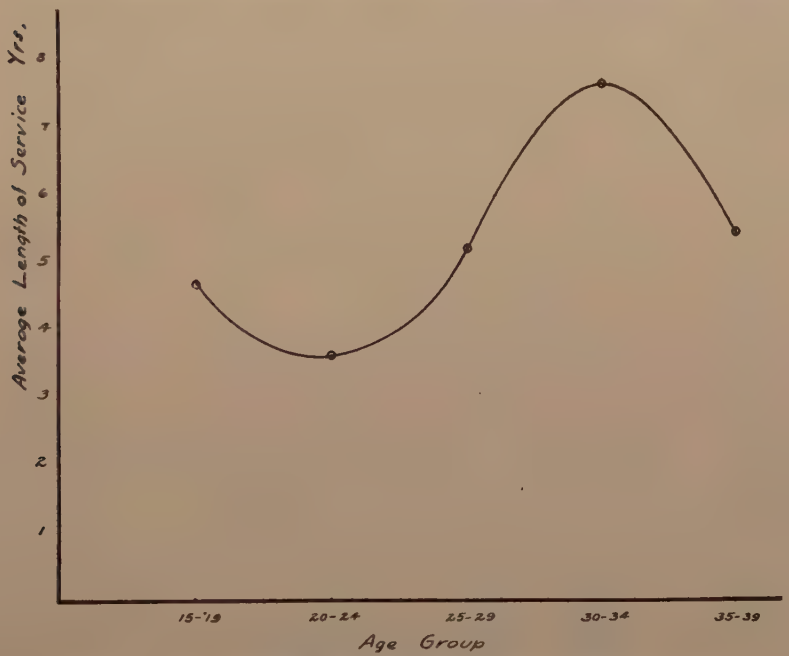

FIG. 27. Graph showing the relationship of age to length of service

with the job. After this there is such a rapid decline that the employment of new men beyond the age of 39 is unjustified.

This seems to justify the statement that 15 to 24 years of age represents the period of trial and error in job adjustment. But it may be also that the higher values for the 25–34 group depend partially on family responsibility. The fact that after 35 years of age the turnover increases seems to be an age effect superior to any influence of marital status, since there are more married

men in this group than in any other. Apparently married men asking for jobs at that age are in general undesirables, or have passed the period of "plasticity" when the effects of training are easily received and when habits have not yet been so ingrained

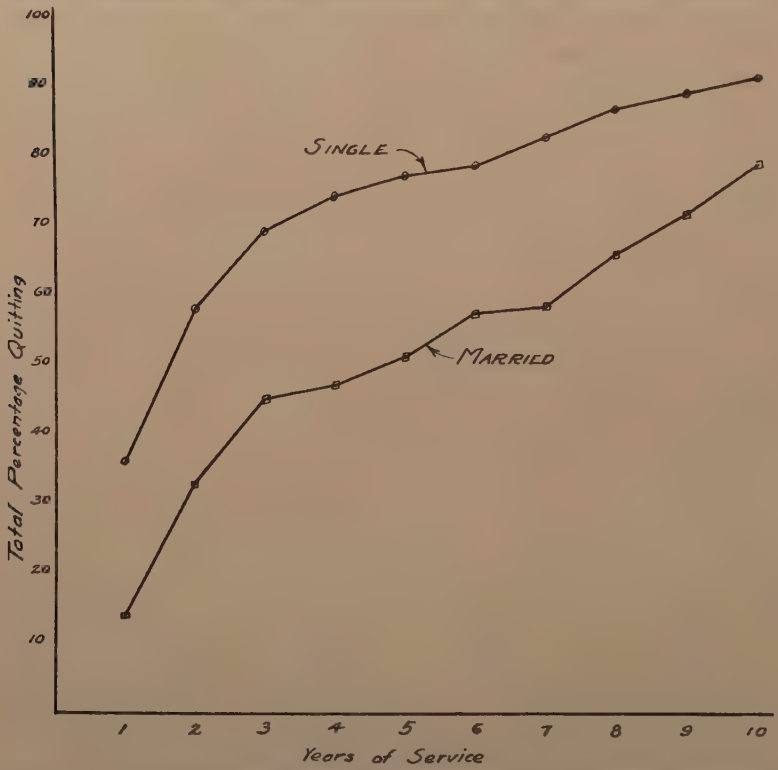

FIG. 28. Cumulative percentage of labor turnover for various lengths of service

The average age of the single men at hiring was 21.3 years; that of the married men, 26.1 years.

as to be unbreakable. Because of this possibility we believe in a considerable amount of leniency for the 20–24 group whose high turnover rate might be considered too seriously.

In the second graph (Fig. 28) we have shown the plotting of cumulative turnover against years of service, giving the curves

for married men apart from those of single men. The conspicuous element seems to be that the turnover percentage for single men is greater than for married men by a nearly constant amount for all lengths of service. It requires seven years of service to produce as much turnover among married men as would be present in two years of service by single men. It requires ten years of service by married men to produce as much turnover as would be present in six years of service by single men. Over one half of all single men quit before their first two years of training have expired. Only one third of the married men quit in the same period. The percentage and probability figures are given in the following table:

TABLE I

THE RELATION OF MARITAL STATUS TO LENGTH OF SERVICE

Number of years of service	Percentage of single men quitting	Percentage of married men quitting	Difference
1	36	14	22
2	58	33	25
3	69	45	24
4	74	47	27
5	77	51	26
6	78	57	21
7	82	58	24
8	86	65	21
9	88	71	17
10	90	78	12

The average age of a single man at the time of hiring was 21.3 years; while the average age of the married men at the time of hiring was 26.1 years.

In summary we may say that the following points seem substantiated by these measurements:

1. The ages 15 to 24 present the probability of the greater numbers of drifters, caused by trial and error job adaptation.

2. Marital status gives an incentive to greater job steadiness, and is about 1.5 times as important as age.

3. Beyond the age of 35 the decrease in job adaptibility is so great as to overcome the beneficial effects of family responsibility.

University of Michigan

SOME INCIDENTAL EXPERIMENTS WITH THE MEMORY PRODIGY, DR. RÜCKLE

THORLEIF G. HEGGE

SOME years ago I had the opportunity of making with G. Rückle, a German doctor of mathematics, a few experiments on which I have not reported before. According to the very extensive investigations by G. E. Müller in Göttingen,[1] as a learner of digits Rückle by far surpasses any other memory prodigy till now known in psychology and studied by corresponding methods. For instance, when tested with a series of no fewer than 408 digits he proved able to learn it in 26 minutes and 47 seconds.[2] This unique feat of memory is made possible largely by his method of memorizing. He has an extensive and marvelous ready knowledge of the characteristics and relations of numbers, and during learning he is able to apply this knowledge to the particular numbers with astonishing ease and rapidity. Probably, however, he does not know beforehand what associative aid he is going to use for each of the numbers which may occur. He finds most of the aids while memorizing. For instance, he knows beforehand that $451 = 11 \times 41$, and he also knows that $697 = 17 \times 41$. During learning, however, this particular relation between the two parts of the number 451697 occurs to him for the first time. There is a great deal of spontaneous reasoning in Rückle's learning of digits.

Since Müller's last tests, which were given in 1912, Rückle had spent years in the war, but in 1920, when I met him, although now more than 40 years old, he was still at the height of his capacities in the field of numbers.[3] I was working along a different line

[1] G. E. Müller, "Zur Analyse der Gedächtnistätigkeit und des Vorstellungsverlaufes," *Zeitschrift für Psychologie*, Ergänzungsband 5; "Neue Versuche mit Rückle," *Zeitschrift für Psychologie*, Bd. 67.

[2] *Zeitschrift für Psychologie*, 67: 195.

[3] Oswald Kroh, *Eine einzigartige Begabung und deren psychologische Analyse*. Göttingen, Vandenhoek & Ruprecht, 1922.

with experimental conditions never tried with Rückle before. I had previously worked with another memory prodigy, Miss B., who had proved to possess a unique ability to recall enormously long series of disconnected words, after having heard them only once.[4] Now I had pointed out that Miss B.'s performances were entirely dependent upon her ability to combine the links of the series to a meaningful whole and that her superiority over other subjects was mainly due to her superiority in doing this in a very adequate way.

So my problem was: Would Rückle be able to compete with Miss B. in this type of learning?

There seemed to be several reasons for believing that he would; or at least that the experiments soon would indicate that he might be able to compete after some training. His general intelligence is normal, or probably even above the average, his field of interests wide, and his visual imagery extremely concrete and detailed. In his own field he is unsurpassed in the ability to find associative aids of high value to memory, and in going on with this work with utmost concentration and speed uninterruptedly through a series of several hundred digits. How would his score turn out in experiments where the ability to connect not digits but words, in a meaningful way, is of fundamental importance? His memory for words that *are* already connected in this way seems to be considerably above the average. When tested with a part of the first song of Byron's *Childe Harold* he was able to give a correct report after 70 seconds, while in Lottie Steffens' experiments, a very rapid learner needed

[4] Thorleif G. Hegge: *Zeitschrift für angewandte Psychologie*, 6:52; *Bidrag til Analysen av Hukommelsen* 1. Kristiania, 1918 (also *Zeitschrift für Psychologie*, 84:349); *Samtiden*, Oslo, Norway, H. Aschehoug & Co., 1919 (also in *Praktische Psychologie*, Bd. 3, and *Zeitschrift für Psychologie*, 84:353); *Zeitschrift für angewandte Psychologie, Beiheft* 29 (also in *Bericht über den 7. Kongress für experimentelle Psychologie in Marburg* 1921); *Klinische Wochenschrift*, 1 (Nr. 15): 742; *The Scandinavian Scientific Review*, Vol. 2, No. 1; *Zeitschrift für angewandte Psychologie*, Bd. 22, 1923; *Zeitschrift für Psychologie*, Bd. 93 (1923): 319 (also *Bericht über den 8. Kongress für experimentelle Psychologie in Leipzig* 1923); "Zur Analyse des Lernens mit sinnvoller Verknüpfung," *Zeitschrift für Psychologie*, Ergänzungsband 13, 1927, Leipzig, Johann Ambrosius Barth.

110 seconds to learn the same material.[5] One would think that the opportunity of competing on the basis of ability to *construct* those meaningful connections for which he had already proved to have a memory above the average, would place a man like Rückle in a much higher rank. The learning of a long series of words in this way seems to demand general abilities closely similar to those that he had already proved himself to possess in an extremely high degree. He would, it is true, not have the advantage of using his unique knowledge in the field of numbers this time. But on the other hand he was not supposed to produce feats of extremely rapid learning and the associative aids he was supposed to use do not presuppose any special knowledge, but, rather, just ordinary experience and a certain capacity for visual imagination, recall of ideas, choice between different possibilities, and concrete imaginative combination. No special knowledge could give any other subject any advantage over him, and as to training in this kind of learning, it would be possible to compare him with other subjects, especially Miss B., on a fair basis.

I started with a series of one hundred disconnected nouns of concrete meaning which I intended to read to the subject only once, one word every ten seconds. The instruction given to the subject as to the method of memorizing was: "You know what it is all about. You must visualize the objects and living beings mentioned and imagine a place, say a landscape, where you can place those imagined objects and living beings. Moreover you must connect them with one another in a meaningful way, forming smaller complexes, and also connecting these smaller complexes to a meaningful whole. You must try to make a *story* out of the words, mainly by making the living beings act with the objects in a way natural to them. You must imagine a connected train of dramatic events, of natural causes and effects. Be careful to connect *all* the links of the series with that one place chosen, and to have the spatial arrangement and the order of events correspond to the order of the words of the series."

[5] Müller, *Zeitschrift für Psychologie*, Ergänzungsband 5:196; Steffens, *Zeitschrift für Psychologie*, 22 (1900): 331.

In addition it may be mentioned that Rückle knew about Miss B. and her results, and that his real aim in these tests was to compete with her. He started out very optimistic as to his chances in this match and all the time he was considerably encouraged by me and by others, to whose opinion he paid a great deal of attention. All the time he was told that he did very well and that even Miss B. would not have been able to obtain such results with such a minimum of training. Rückle's physical condition was excellent and he certainly would not have agreed to coöperate if it had not been.

The score for the spontaneous recall was: 64 words right, 29 omitted, 7 misplaced. In the second recall, during which he was corrected by me, the score obtained was: 79 words right, 1 substituted (one word replaced by another of similar meaning), 15 omitted, 5 misplaced.

Now, considering that this series was the first that Rückle ever learned with me, this result should have been quite satisfactory if it had been obtained under the conditions which I had intended to use. This, however, was not the case. The series was first read to the subject once with 10 seconds for each word according to the plan; then, at his request, for a second time with 5 seconds for each word. In other words, as compared with Miss B. and my other subjects, Rückle had the immense advantage of having the opportunity for memorizing the series *twice*. He simply did not feel able to recall any considerable number of the words after the first reading. He was not discouraged, however, but believed that training would cause a marked improvement.

The next opportunity for an experiment with Rückle appeared half a year later. A series of 100 new words, of the kind described before, was read to the subject only once, with a period of 10 seconds for each word. The score for the spontaneous recall was: right 44, substituted 2, misplaced 12, omitted 42. The score for the second recall, during which he was corrected by me, was: right 71, substituted 4, misplaced 9, omitted 16.

This result is quite good; it even approaches those of Miss B., who in three series of 100 words of the same kind and

under very similar experimental conditions, obtained the following scores:

Omissions	Substitutions
4	2
8	2
3	4

The misplacements were not counted in these experiments. They occurred very seldom. If, however, we consider only the omissions and the substitutions in the experiment with Rückle, his score appears fairly high. The first of the foregoing series was one of the first ever memorized by Miss B.

The distribution of errors in recall points, however, to a limitation in Rückle's abilities. If there is no collapse of the memorizing ability the errors in recall will be fairly equally distributed over all the series; if there have been one or several collapses, the errors will appear in large groups, especially towards the end of the series. This was evidently the case with Rückle. In the first series the bulk of the errors falls between the fortieth and the eightieth words, which evidently means a collapse of the memorizing ability at the fortieth word, since the series was memorized twice and the recall of the last twenty words could be secured by mechanical memorizing and by writing them down first. In the second series Rückle interrupted his spontaneous recall with the sixty-fourth word, feeling unable to recall anything more spontaneously. Up to that point he had done fairly well. The second recall showed a very marked improvement for this first part of the series. Among the first 64 words there are now 6 omissions, 3 misplacements, 2 substitutions. Among the last 36 words there are still 10 omissions, 6 misplacements, 2 substitutions. In the first group of 64 words during the second recall I reminded the subject 20 times; in 9 of these cases he found the missing word. In the second group of 36 words I reminded the subject 19 times, only once with success. Such a collapse of the memorizing ability was never found in Miss B., even in much longer series, or before she had had any considerable training. In a comparatively short series of 100 words it was not found in several untrained subjects, who

never could think of obtaining scores like Miss B. in longer series. Rückle himself admitted that the ability to find associative aids had been seriously inhibited towards the end of the series.

The third experiment with Rückle was carried out four days later. It was of the same kind as the previous one, except that the memorization period for each word had on Rückle's request been changed from 10 to 7 seconds. The result this time was a complete failure. In the spontaneous recall he found ten words in the beginning of the series in 3 minutes and 30 seconds. Then he gave up and asked me to read the series once more, this time with a memorization period of 3 seconds for each word. After the second memorization he again started the spontaneous recall, but with just as little success as before. I then read the series to him for the third time, again with a speed of 3 seconds for each word. Rückle then tried to recall the series once more and I corrected his errors just as usual in the second recall. In this way we proceeded with the first twenty words of the series and then had to give up. There were 3 omissions among those twenty words after three memorizations. Rückle declared afterwards that he was not well disposed for learning this kind of series that morning. He admitted, however, that he might have been able to learn series of digits with the usual result, as they would have stimulated him. This too calls for a comparison with Miss B., who never was indisposed for learning word-series and always was stimulated by the learning itself.

His friends and I now strongly encouraged Rückle to try again under different conditions. It was pointed out to him that the conditions had not been fair to him, that one ought to offer him conditions as closely similar to the accustomed ones as possible. He also ought to be free to choose the method of memorizing which suited him best and might promise the best results. Rückle himself was very desirous to prove his ability and so the next test was given on the following morning. Rückle was in perfect condition and anxious to start over again.

A series of one hundred words, constructed according to the same principles as the previous ones, was presented simultaneously.

It was written in ten lines on a sheet of paper which was given to Rückle. This presentation was analogous to that of most of the digit-series. And the same was the case with his task: he was to learn the series as rapidly as possible for correct immediate recall and he might learn it in the way most suitable for him.

The result, however, did not even this time indicate any superior learning ability. Rückle needed no less than 31 minutes and 40 seconds to learn the series, which means that, on the average, he used 19 seconds for each word, which again indicates that he might have had the opportunity of memorizing nearly the whole series twice in the same time if it had been presented orally with a speed of 10 seconds for each word. And in spite of this length of learning time, and also in spite of the instruction to learn the series for perfect recall, the recall contained 6 omissions and he found 1 word after having been reminded. His method of memorizing had been essentially the same as before.

Two days later I had the opportunity of having one more session with Rückle. It was to be the last one. In this experiment, however, he was interrupted several times during learning and asked to report on the processes of memorizing so that it was of no use to have him recall the series afterwards. I was sorry that circumstances thus prevented me from obtaining more material with this extremely interesting subject. Because of the scientific importance of the case in general, however, I have considered it my duty to present what material I have been able to obtain, believing that *any* new information concerning this memory prodigy may sooner or later prove to be valuable.

The results present to us the somewhat peculiar picture of a man with superior general abilities of importance to logical learning, who in one field of learning displays a unique ability to find logical relations and to learn and recall the series with almost supernatural speed, but who in a related field drops down to, or at least approaches, the level of an ordinary learner. I am not very much inclined to believe that continued training would have caused considerable improvement. His method of memorizing was uniformly ineffective and he was unable to change it and to follow the instructions strictly. One might expect a man like

Rückle, so superior in devising his own learning methods, to have shown some indication of improvement in five tests, if there had been any possibility of such improvement. If his results in some cases are somewhat above the average, this is due, not to his method, but to his superior ability to remember what he did during learning, even if what he did was wrong, and to the mere retentiveness of his visual and rote memory. In still more difficult tasks, however, where his rote memory would not help him out, the quality of the method and the ability to find associative aids would be decisive.

In a certain sense his memory, as his introspective reports show, is also his main difficulty. Each word stirs up in him numerous definite and detailed memory images from the most different periods of his life. He tried continually but in vain to inhibit this tendency. The memory images confuse him and make impossible a successful free constructive imagination, such as is required by the learning task. Consequently he is to a large extent forced to rely on not very valuable abstract considerations and on mechanical memorizing. An emotional reaction unfavorable to learning and a collapse of the learning ability are the result in each series.

Royal University of Norway

INTESTINAL ABSORPTION OF ACIDS AND ITS BEARING ON THE CAUSATION OF ANEMIA

EPHRAIM B. BOLDYREFF

INTRODUCTORY

A CERTAIN degree of relationship between digestive troubles and the development of anemia is well established. In a detailed clinical study of several hundred cases made by W. H. Riley (16) with special reference to the involvement of the nervous system in pernicious anemia, the digestive disturbances and pathological changes were also carefully noted. In regard to the digestive troubles and their relation to the anemia, Riley makes the following statement: "The digestive system was attacked first in nearly all cases, as indicated by disturbances of digestion, achylia, attacks of diarrhea, and other symptoms relating to the digestive tract."

The significance of digestive symptoms in anemia had been observed and reported also by hematologists. Gulland and Goodall (7) state: "Attacks of diarrhea occur with great frequency, and are often associated with the attacks of sickness" (anemia).

During recent years a number of investigators have again called attention to the significance of intestinal symptoms in anemia. Landau, Cygielstrejch and Fejgin (9) report several cases of hypochylia and achylia pancreatica associated with pernicious anemia. Mouzon (13) gives a thorough review of new work on the subject. He mentions the insufficiency of the secretion of pancreatic juice in anemia, discusses the absorption of the toxins produced in the intestine and points out their significance in this malady. The acid fermentation, according to many investigators (5, 12), "is typical and found in every case of pernicious anemia."

Kolmer (8) showed that acids and alkalies possess a strong hemolytic action; the amount of acid required to produce a certain degree of hemolysis was in his experiments found to be several times less than the amount of alkali of the same strength needed to obtain the same degree of hemolysis. This shows that acids possess much stronger hemolytic action than alkalies.

The object of this present work is to study the effect of absorption of acids from the intestine upon the red blood corpuscles.

The acidity of the gastric juice of higher animals, as it is secreted from the gastric glands, is about 0.5 per cent HCl, or approximately three times greater than the optimum acidity required for peptic digestion. Such high acidity at the beginning of digestion is needed not so much for the digestion of the food as for its disinfection.

W. N. Boldyreff (4) has proved, and it is now generally accepted, that in the normal organism during digestion, as well as in the empty stomach, the gastric acidity is regulated by the alkali of the pancreatic juice regurgitated from the duodenum into the stomach. The partial neutralization thus effected usually lowers the gastric acidity to 0.15 per cent HCl.

Also it was shown experimentally in Boldyreff's laboratory at the Imperial University of Kazan by N. A. Milovzoroff (4) that the acidity of the gastric contents is quite low when it reaches the small intestine. Often it is found to be as low as 0.05 per cent in the upper part of the jejunum.

This almost complete neutralization of acids in the small intestine is quite significant. The intestine tolerates hydrochloric acid in the concentration of about 0.15 per cent, but the absorption of acids from the intestine by the blood is harmful for the organism (2). The presence of acids in higher concentration in the stomach is not harmful because there is no absorption of aqueous solutions from the fundus of the stomach.

It is known that some acids have a destructive effect upon the red blood corpuscles and are used in laboratory practice as their solvent (acetic acid, for instance, in the pipette method of leucocyte count). Therefore, hypothetically, one would expect to find the same condition produced by acids in the animal body,

after elimination of the neutralizing effect of the pancreatic juice.

The effect of acids absorbed from the intestine on the red blood cells was studied in healthy dogs. The whole length of the intestinal tract was used for the experiments and the same phenomena were invariably observed.

EXPERIMENTAL

The following experiments were performed:

1. Acids of low concentration were introduced into the intestine and estimations were made of the changes in the number of erythrocytes per c.mm. of blood. The possible neutralization of acids in the intestine by the alkali of the pancreatic juice was excluded.

2. A study was made of the changes in the number of red blood corpuscles due to introduction of acids into the intestine. The possible neutralization of the acids by the alkali of the pancreatic juice was not excluded.

3. The effect of the ligation of the pancreatic ducts upon the erythrocytes in the blood was studied.

4. Chronic anemia produced by daily administrations of hydrochloric and lactic acids through the gastric fistula was studied.

The blood counts were taken before the introduction of acids in the intestine and at hourly intervals after the introduction of the acid. In the case of the ligation of the pancreatic ducts the normal blood count was established previous to the operation, and in order to make sure that the changes in the red cell count were not caused by possible loss of blood during the operation a parallel series of control blood counts were carried out on another dog operated upon in the same region of the abdomen (biliary fistula) and on the same day (see Table III).

The acid solutions chosen for the experiments were of the kind and strength likely to be present in the gastro-intestinal tract in normal conditions. The following substances were used: (1) dog's natural gastric juice with admixture of raw egg-white (from 15 to 25 per cent of egg white by volume), in which acidity of the mixture varied from 0.44 to 0.28 per cent HCl; (2) 0.5

per cent hydrochloric acid; (3) 0.8 per cent acetic acid; (4) 1.25 per cent lactic acid; and (5) fresh lemon juice; 6.14 per cent citric acid. Egg-white was added to the gastric juice in order to bind the pepsin and to render it less irritating to the intestinal mucosa. The experiments were of different duration, ranging from ten hours of uninterrupted observation to two months of daily observations.

1. *Destructive action of intestinal absorption of acids on the erythrocytes, the neutralizing agency of pancreatic juice being excluded*

The effect of the absorption of acids was studied on dogs with an isolated loop of the small intestine after Thiry-Vella and also on dogs with the temporary surgical isolation of the intestine from the duodenum by the ligation of the bowel (experiments of March 10 and March 17, 1927).

The dogs with the Thiry-Vella fistulae were:

1. Dog No. 22, male, 5 years old; collie, weighing 24,200 grams. The middle of the jejunum was used for the isolated loop; length 45 cm.

2. Dog No. 27, male, 3 years old; mongrel, weighing 20,300 grams. The beginning of the jejunum was used for the isolated loop. Length of the isolated portion 25 cm.

The other two dogs were young females: one an 8-month-old mongrel collie weighing 9,000 grams, and the other a 6-month-old police-beagle weighing 9,120 grams. The first had the small intestine ligated below the pancreatic ducts. The second had the large intestine ligated at the cecum and at the end of the rectum. These two dogs were under chloretone narcosis during the experiments.

The experiments on dogs No. 22 and No. 27 with the Thiry-Vella fistulae were repeated several times. In each case ample time was allowed for recovery from the effect of the preceding experiment. The results obtained were similar in all experiments on all dogs. The complete absorption of acid solutions by the blood usually followed the introduction in from about 10 to 20 minutes. Thus neutralization or dilution of acids in the intestine by the intestinal secretion was practically negligible.

The following changes were observed: decrease of the erythrocytes and occasionally varied degrees of leucocytosis. The decrease in the number of erythrocytes was usually noticed in from $1\frac{1}{2}$ to 4 hours after the acid solution was absorbed from the intestine. The decrease of erythrocytes was from 1,000,000 to 2,000,000. The number of red blood cells was restored later to the normal, but rather slowly. Below are tabulated the changes in number of erythrocytes due to the absorption of acids from intestine.

TABLE I

THE DESTRUCTION OF ERYTHROCYTES BY ACIDS ABSORBED FROM INTESTINE

Neutralization by pancreatic juice was excluded

Date 1927	Normal R.C.C.	Acid used	2d hour	4th hour	6th hour	8th hour	10th hour	24th hour	77th hour
Feb. 10	4850000	140 c. c. gast. juice	4090000	3860000					
Feb. 25	4800000	120 c. c. gast. juice	4700000	3840000					
March 10	4410000	200 CH_3COOH		4300000	3730000				
March 17	4070000	200 c.c. HCl		3260000					
April 4	4980000	200 c. c. lemon juice	5050000	3090000	3280000	3670000	3800000	3790000	4770000
April 22	5000000	110 c. c. lactic acid	5100000	3400000	3800000				

II. *Effect of the introduction of acids into the stomach upon red blood corpuscles*

In these experiments neutralization of acids by the alkali of the pancreatic juice was not excluded. The dog used for these experiments was operated upon 6 months previous to the beginning of the experimental work. It was a male fox hound-beagle, about 4 years old, weighing 13,440 grams. The dog had simple gastric fistula. The introduction of 1.25 per cent lactic acid into the dog's stomach caused a decrease in the number of erythrocytes per c. mm. of blood. The change, however, was not as pronounced as in the experiments described above. Much

greater quantities of acid solution were required to produce a noticeable effect, owing to the partial neutralization of acid by the pancreatic juice. The examples given below may serve as an illustration.

TABLE II

Destruction of Erythrocytes by Acids Absorbed from Intestine

Date	Normal R.C.C.	Quantity of acid	2d hour	4th hour	6th hour
Nov. 1, 1926	5,030,000	200 c.c.	5,050,000	4,950,000	5,070,000
May 31, 1927	5,000,000	400 c.c.	3,930,000	5,000,000	4,940,000

In these experiments 200 c.c. and 400 c.c. of 1.25 per cent lactic acid solution were introduced into the stomach.

III. *Temporary anemia caused by the ligation of the pancreatic ducts*

Very interesting phenomena, which followed the ligation of Wirsung's and Santorini's pancreatic ducts, were observed in my recent experiments (3). A healthy 3-year-old male dog with normal digestion, normal blood sugar, normal blood coagulation time and normal blood count soon after the ligation developed the following symptoms: vomiting, diarrhea, high blood sugar, low coagulability of the blood, leucocytosis, enormous appetite and thirst, loss of weight and a tendency to develop anemia.

These pathological conditions lasted for over a month; the animal then gradually recovered: the blood sugar dropped down to the normal level, the dog gained in weight, the digestive disturbances disappeared and the erythrocyte count returned almost to normal. Evidently the secretion of pancreatic juice in the intestine was restored (10, 14). The formation of new ducts was confirmed in this case by autopsy one year later, when the dog died from an accidental cause.

TABLE III

TEMPORARY ANEMIA CAUSED IN DOGS BY THE LIGATION OF PANCREATIC DUCTS

Date Dog No. 1	3-28-27	3-29-27	3-30-27	3-31-27	4-1-27	4-5-27	5-3-27	5-12-27	5-27-27
Weight	14.800	Ligation of pancreatic ducts				13.700	14.000	16.000	17.000
Leucocytes	7,500				16,800	6,000	8,500	6,300	
Red cells	4,860,000				4,410,000	4,140,000	3,810,000	3,600,000	4,450,000
Blood coagulation	32 sec.				2 min. 50	1 min. 10	2 min.	45 sec.	
Blood sugar	0.095				0.118	0.120	0.095	0.097	
Condition of digestive canal	Normal		Vomiting and diarrhea	Strong vomiting and diarrhea	Vomiting and strong diarrhea	Strong diarrhea	Better (diarrhea)	Normal	Normal
Condition of wound			Fair	Skin wound opened	Poor	Poor	Wound healed	Good	Good
Dog No. 2									
Weight	18.730	Biliary fistula							19.070
Leucocytes	6,600			6,900	12,300	6,600			
Red cells	4,650,000			4,700,000	4,600,000	4,640,000			
Blood coagulation	25 sec.			25 sec.	25 sec.	25 sec.			
Blood sugar	0.100				0.091	0.090		0.100	
Condition of digestive canal	Normal		Normal	Normal	Normal	Normal	Normal	Normal	Normal
Condition of wound			Good	Good	Good	Primary intention	Good	Good	Good

On the foregoing table are given two series of observations. The upper part shows the phenomena which followed the ligation of pancreatic ducts; the lower part represents the control observations made on another dog operated upon in the same region of the abdomen (fistula of the gall-bladder). From the table it can be seen that the surgical procedure alone did not bring about the diminution of the number of erythrocytes on the first dog.

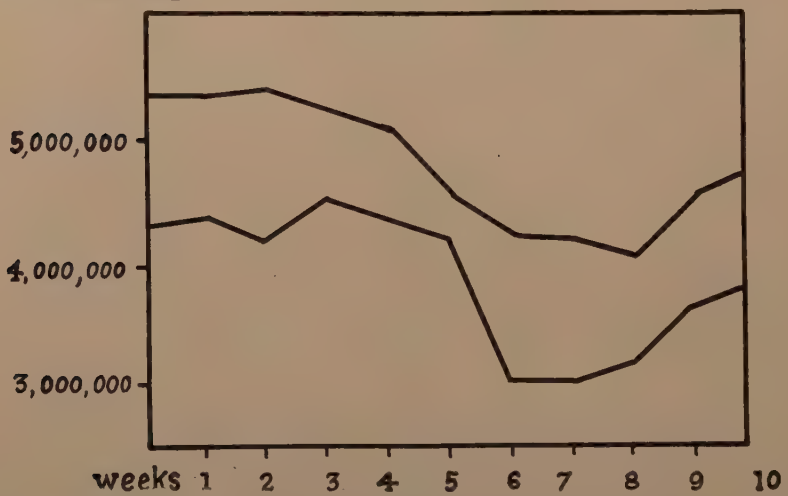

FIG. 29. Chronic anemia experimentally produced in dogs

Upper line shows the decrease in number of erythrocytes per c. mm. in dog No. 1, male; lower line, in dog No. 2, female.
Administration of acids was continued for only six weeks; the purpose of this experiment was to demonstrate the development of anemia due to intestinal absorption of acids and likewise to show the gradual recovery effected by the removal of the cause responsible for the diseased condition.

IV. *Experimental anemia produced by administration of acids in the stomach*

My recent experiments on two dogs with the daily administration of acids showed a definite decrease in the number of erythrocytes due to intestinal absorption of acids. In one case a healthy male dog, weighing 20,020 grams, had 5,300,000 red cells per c. mm. of blood at the beginning of the experiments;

six weeks later the red cell count gradually dropped to 4,200,000 per c. mm. In the other case, a female dog, weighing 17,300 grams at the beginning of the experiments, had 4,300,000 erythrocytes per c. mm. of blood; six weeks later the red cell count was 3,020,000 (see Fig. 29). (This dog had, as was previously established, marked deficiency of pancreatic function.) Loss of weight was also observed in both dogs: The first lost 3 kilograms and the second about 3½ kilograms in two months. The blood picture showed not only decrease in the number of erythrocytes, but also the presence of pathological forms — crenated cells, poikilocytes and uneven distribution of hemoglobin.

The administration of acids in the stomach was started on these dogs on September 7, 1927, and was discontinued on October 21, 1927. The prevalence of anemia, however, persisted for two months longer; even then the gain in weight and increase in number of erythrocytes in the blood were rather slow. The last determinations gave the following figures: the first dog, weight 18,450, red cell count 4,680,000; the second dog, weight 15,000, red cell count 3,800,000.

The hemoglobin estimations showed also a decrease in the amount of hemoglobin in the blood.

DISCUSSION

It is of interest to note that in pernicious anemia the progressive decrease of the number of red cells is generally attributed to the destruction rather than to deficient production of erythrocytes. In the experimental part of this article is given direct evidence of the destructive hemolytic action of acids absorbed from the intestine upon erythrocytes. In Table III it is shown (see p. 403) that exclusion of pancreatic juice results in a decrease of the number of red blood corpuscles and a rise of blood sugar content. In the literature also are found some remarks on the relation between changes in erythrocyte count and blood sugar curve. Meulengracht and Iversen (11) report increase of blood sugar content in cases of pernicious anemia in fasting individuals, as well as the lessened sugar tolerance.

The increased sugar content in cases of anemia and occurrence

of acidosis, which is also prevalent in cases of severe diabetes as well as acid fermentation in the colon, are very suggestive. Barr and Peters (1) have studied the carbon dioxide combining power of the blood in six patients with severe anemia and report "a tendency to accumulation of CO_2 in the tissues."

Through the courtesy of the associate director of the Battle Creek Sanitarium, Dr. Charles E. Stewart, I had the opportunity to study about one hundred cases of anemia with special reference to the alveolar CO_2 tension and presence of acetone in the breath. Few of these cases are presented in the table given below. A great number of these cases manifested a varied degree of acidosis or a marked tendency toward it, indicating the diminution of the alkaline reserve of the blood. Thus the lowering of the alkalinity of the blood may be considered as a possible factor in the development of anemia.

A great many of the cases studied manifested also intestinal toxemia. Minot and Murphy in their recent publication on the treatment of pernicious anemia, discussing the diet most suitable for patients suffering from this malady, advise the avoidance of foods which are apt to promote "an acid fermentation in the colon so common in these patients with achylia or achlorhydria" (12).

Hunter and, especially, Van den Bergh (6) point out the great increase in the hemolysis, "A cellular destruction of the red corpuscles" as a "basal pathological event" in development of pernicious anemia. There are also indications that the administration of acids to anemic patients should be done with the utmost caution (15).

Every biological process takes place at a certain favorable reaction; there is an optimum condition dependent on the reaction of surrounding media. The maintenance of an optimum reaction is a primary requirement for existence of an organism or an individual cell.

The normal reaction of blood plasma is slightly alkaline; the pH of human blood is equal to 7.36. This optimum reaction is maintained by the alkaline reserve of blood.

The accumulation of acids in the organism diminishes the

alkaline reserve and produces the condition known as acidosis. For the determination of the degree of acidosis in the clinical practice the estimation of the amount of carbon dioxide in the expired air is usually employed. The normal values are from 40 to 50; lower figures show different degrees of acidosis. The figures given below were obtained with a very few exceptions through application of Roth's method of determination of alveolar CO_2 tension (17).

TABLE IV

DIMINISHED ALKALINE RESERVE OF BLOOD IN PERNICIOUS ANEMIA: HUMAN SUBJECTS

Case No.	Red cells	Alveolar CO_2 tension	Acetone
1	1,350,000	28	tr
2	2,030,000	30	tr
3	2,060,000	30	tr
4	2,800,000	31	tr
5	2,880,000	30	tr
6	2,200,000	33	tr
7	2,040,000	33	tr
8	2,980,000	34	+
9	2,070,000	35	+ + +
10	1,560,000	35	tr
11	2,230,000	36	+
12	3,220,000	33	tr
13	4,000,000	35	+
14	4,700,000	34	+
15	4,900,000	41	+ +

SUMMARY

The experimental evidence given in this article shows that absorption of acids from the intestine has a destructive effect upon the erythrocytes in the blood. In the normal organism the acidity of the gastro-intestinal contents is regulated by the alkaline pancreatic secretion, and in this way the harmful effect of the absorption of acids from the intestine is eliminated. A deficiency in

the secretion of pancreatic juice hinders its neutralizing agency and therefore is apt to predispose to the development of anemia. This is confirmed by experiments with the ligation of the pancreatic ducts. Therefore, could not rational therapy aimed at the restoration of normal acid-base balance in the intestine prove to be of some advantage in cases of deficiency in the natural neutralizing agent — pancreatic secretion?

Intestinal absorption was studied through the whole length of the intestinal canal. The destructive effect of acids upon erythrocytes was always noticed, but it was much more pronounced in the small intestine. The decrease in the number of red cells varied from 1,000,000 to 2,000,000. The clinical study of cases of pernicious anemia reveals the prevalence of acidosis in this malady which is sometimes associated with high blood sugar. The study of the phenomena of intestinal absorption and their relation to anemia is to be continued.

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A PRELIMINARY SURVEY OF DEERYARDS IN THE UPPER PENINSULA OF MICHIGAN

ILO H. BARTLETT AND JOSEPH H. STEPHENSON

FOR a number of years the status and the future of the deeryards in northern Michigan have been a concern of the Department of Conservation and others interested in the protection and development of our wild life resources. It has been assumed that a large number of yards were in jeopardy from various causes, such as the destruction of essential cover by lumbering operations and fire. It seems to be generally assumed, also, that the only way to preserve or protect the yards is through state control.

Some years ago vague questionnaires were sent out seeking information as to the locations of important yards, but the very scant returns were never compiled or used.

Late in 1927 printed forms were widely distributed to conservation officers, sportsmen's organizations, etc., and more than one hundred replies were received. The deeryard locations, as reported, were spotted on maps of the Upper Peninsula. These maps were then sent to district conservation officers who were asked to designate their first, second, and third choices, for early survey. These double recommendations were then plotted on county maps and the winter accessibility of each unit was determined by further correspondence with the district officers.

In the meantime, we corresponded with the presumed authorities in Washington and at various technical institutions, asking for detailed information covering deeryards, and comparative surveys thereof, but no such data seemed to be available. We were, therefore, forced to devise our own technic and procedure.

Some two feet of snow fell about the middle of November, and the deer began to yard about that time. The depth of snow

did not increase perceptibly until about the first of the year and when we reached the yards in January the deer seemed to be fairly well congregated. For several weeks we visited a series of the more important yards, spending a day or two in each. We hoped to discover the range and variation of typical yards, so that some practical grouping or classification of the different types might be made. After this preliminary survey of a number of yards, it was decided that the majority would fall into the following three classes:

Cedar yards — found mostly in the eastern portion of the Upper Peninsula.
Cedar-hardwood yards — found mostly in the central portion.
Hardwood yards — found primarily in the large areas of hardwood in the western part.

The general object of this deeryard survey was to determine the following four main points in relation to each yard:

1. Is the area, as recommended, important as a yard?
2. Is the yard liable to material change of importance during the next ten or twenty years?
3. Is the yard in danger from fire, cutting, or other hazards?
4. Can, and should, the state do anything to protect or improve the yard?

A winter survey should answer, in a large measure, the first two of these points. The answer to the last two must evidently be worked out by summer surveys when the yards are more accessible.

Maps of the cover and of the concentration of deer were the principal accomplishments of this winter's survey. These maps show the degree of stocking, approximate size and predominant species of forest cover; the pattern and degree of deer concentration; the relation of deer concentration to the different types of cover; old and recent cuttings, burns, topography, water, and food supplies.

It was decided to recognize four degrees of concentration in the typical hardwood yards; scattering, light, medium, and heavy,

and the first major problem was to determine the number of deer typical of each degree of concentration.

In an effort to secure reasonably precise data we first tried counting the deer seen in each area. This was soon found to be impracticable, for the number of deer seen along a given compass line was found to vary according to the time of day, weather, and current movement of the herds, not to mention the personal equation of the observer.

The next experiment was to fasten a tally register on a tree close to a well-defined deer trail and fix a wand in such a manner that it extended across the trail and rested on the lever of the register. Deer passing along the trail would make the wand press the lever of the register, thus counting the number of deer that passed. This did not work, however, as the deer were suspicious of the wand and invariably made a trail around it. We think, however, that the scheme can be made to work if a little more time is devoted to perfecting it.

We next tried counting trails per unit of compass line, but this proved undependable, for in the better and more used trails the individual tracks could not be distinguished, and there was no telling whether the trail was used by five or by fifty deer.

It was finally decided that the best approximations were to be obtained by counting the newly made deer beds found after a fresh snowfall. By using a system similar to the forester's "ten per cent cruise," and tallying fresh beds instead of trees, a fairly accurate estimate of the number of beds per acre could be made for each degree of concentration. It was soon realized, however, that a deer was likely to make more than one bed during a night and a day, but, since no data were available on this point, the figures as obtained were used.

The approximate number of deer in each degree of concentration, as determined by this method, follows:

1. Scattering concentration, approximately 5 deer per 40 acres.
2. Light concentration, approximately 10 deer per 40 acres.
3. Medium concentration, approximately 30 deer per 40 acres.
4. Heavy concentration, none observed.

FIG. 30. Section of typical deeryard in hardwood country

Forest Cover Types: P, poplar predominant; H, hardwood with no hemlock; h, hardwood with hemlock; C, swamps with cedar; S, clear spruce swamps; Bu, old burns, open

Roads
Railroads
Lakes
Streams
Logging camps
Summer or hunting cabins

No resident deer
About 5 deer per 40 acres
About 10 deer per 40 acres
About 30 deer per 40 acres

In the hardwood yard, a map of which is attached for illustration (Fig. 30), the average number of deer per square mile was approximately 100, or an average of 1 deer per $6\frac{1}{2}$ acres.

Winter food preferences of the deer are very marked. Although they seem to feed on nearly every variety of tree and shrub, their winter diet in the Upper Peninsula of Michigan is mainly cedar, hemlock, and hardwood browse, depending chiefly on the availability of each. Small trees of these and other species were cut and left along a trail and within a day or two were nearly always browsed clean. The deer seem to browse, more or less, on all the hardwoods, but prefer the maples and ash. Ash has been found browsed down to a thickness of half an inch. Poplar, tamarack, white pine, willow, and alder furnish their share of feed. The lichens, Usnea (sp.), and Alectoria (sp.), found mainly in the wet spruce swamps are evidently a regular item of the diet; also the true moss, Anomodon (sp.).

The following are a few of the many unanswered questions relating to the habits and the future of our Upper Peninsula deer and deeryards.

Why are deer concentrated in certain areas when there appears to be more and better food only a short distance away, and easily accessible? Do wolves, working in an area, tend to drive deer out of that territory? Does the availability of running water tend to locate the yards? Does a deer return to the same yard each winter? What is the reason that deer do not eat much spruce and balsam? When eaten, does such feed have a toxic effect? How serious is the damage resulting from heavy yarding in stands of young cedar? To what degree does a given style of cutting damage or improve a yard of a given type and condition?

From this winter's experience it is quite evident that field work alone is not sufficient to supply all the data needed in order to complete such an investigation. Collateral researches seemingly in order are:

Laboratory investigation of deer feeds to determine the relative food values, and toxic effects, if any.

Study of deer pathology, including post-mortem examinations of bodies of dead deer found in the yards.

Determination of suitable varieties of artificial feed and methods of distributing it.

Forestry experiments to determine the species of second growth which will furnish satisfactory deer food in the shortest period.

Forestry experiments to determine which species of second growth will best stand annual and heavy browsing.

Experiments looking to the wholesale and periodic capture and marking of deer to parallel the bird-banding operations of the U. S. Biological Survey so as to be able to trace the seasonal migrations, and the migrations within the larger yarding areas.

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THE SEXUAL DIMORPHISM OF THE COLLARED LIZARD, *CROTAPHYTUS COLLARIS**

CHARLES E. BURT

THE data for this paper have been gathered in connection with the writer's recent study[1] of the collared lizard, *Crotaphytus collaris* (Say), in which the synonymy of the two commonly recognized subspecies, *Crotaphytus collaris collaris* and *C. collaris baileyi*, was established upon a detailed study of the group as a whole, rather than upon the consideration of purely sexual characteristics.

With our present state of knowledge it is practically impossible to determine accurately the sex of many of our common lizards without resorting to internal dissection, and, furthermore, each related group presents its own series of peculiarities. Thus, Cope (1900, p. 434) has indicated that femoral pores are absent in the females of *Phrynosoma cornutum*, but present in the males. In the subspecies of *P. douglassii*, however, femoral pores were stated to be present in both sexes, with an apparent reduction in their number in the female series. Likewise, a reduction in the number of femoral pores in the females of *Sceloporus merriami* is suggested by data presented by Wright and Wright (1927).

The presence of a transverse series of enlarged plates back of the anus, which are termed "postanals," has often served as a criterion for the determination of the male sex of certain species belonging to the family Iguanidae, and a comparatively greater

* Contributions from the Zoölogical Laboratory of the University of Michigan.

[1] This article, which has been given the title "The Synonymy, Variation and Distribution of the Collared Lizard, *Crotaphytus collaris* (Say)," is to be published in the *Occasional Papers of the Museum of Zoölogy of the University of Michigan*.

width of the tail at its base (due to the presence of the copulatory organs inside) has long been known to be a characteristic of all male lizards. However, in using the last distinction one must be thoroughly familiar with a large series of specimens, and in many cases, he cannot even then be reasonably sure of his decision without first carefully checking it by the consideration of other features.

Although the presence of a striking coloration within a lizard species has usually been correctly assumed to be a male characteristic, there is still room for further consideration, since descriptions of the male alone, or of the species, may have been based wholly upon such individuals. There is also the possibility that part or all of the females may possess almost as brilliant a coloration as the males, the color relationship between the sexes then being that of actual intergradation, rather than that of sharp contrast.

The large males of *Crotaphytus collaris* are very highly colored during the spring mating season. Although, as the year advances, they slowly lose this distinction and become duller in color, they still retain a somewhat darker coloration than the females. Young males, and all females, are never found with their bodies bright green and their throats deeply tinted with orange, as are breeding males, but show a predominance of the grays, browns, yellows, and various other dull colors. In the west and southwest part of its range the collared lizard often shows an extension of its characteristic deep black collar toward the mid-ventral line. As far as observed the union of these elements is found in males only.[2] This condition, however, which is usually accompanied by deep brown or black groin patches, is not constant in all adult males, even in certain favored parts of the range. Moreover, it has not been observed in the young, a fact which suggests that it is possibly a secondary sexual characteristic.

Except for a few border-line cases in young examples, the presence of an enlarged series of postanal plates may be considered

[2] In case of the establishment of the synonymy of *C. dickersonae* Schmidt (1922) with that of *C. collaris* (Say), an exception to this distinction may result, since the type of that species (described from a single specimen characterized by a mid-ventral union of the collar) was listed as a female.

characteristic of the male collared lizard, and only a very slight enlargement, if any, as characteristic of the female. The accompanying illustration (Pl. XXIII) shows this distinction very well, and in addition another which has been of even greater use to the writer, that of *enlarged femoral pores in the male* and noticeably smaller femoral pores in the female. In regard to the examination of a femoral pore, it may be stated that it is well to focus one's attention upon its diameter. The center may or may not be filled with a plug, which, though hardly apparent in most females, is usually easily seen in the males. The difference becomes greater with age, and in adults is more marked during the breeding season. By a combination study of coloration, postanal plates, femoral pores, and the width of the base of the tail, one may be fairly certain of the sex of any given specimen, as indicated by numerous internal dissections.

After an examination of a series of specimens of *Crotaphytus insularis*, *Holbrookia maculata maculata*, *Sceloporus undulatus undulatus*, *Sceloporus undulatus thayerii* and *Callisaurus ventralis ventralis*, it appears that their sex may also be ascertained by the same general method,[3] and this suggests that it may be applied to other Iguanidae.

Data obtained from the examination of 1256 collared lizards serve as the basis for the following table of sexual dimorphism. Averages have been obtained, after the arrangement of the data in a reasonable number of mid-class values, by the division of the sum (3) of the product of the frequencies (f) times the mid-class values (m) by the number of lizards involved (n).

$$\text{Hence, average} = \frac{3\,(fm)}{n}.$$

The extremes of the ranges in variation are presented in the paper referred to at the beginning of this article and will not be repeated here.

[3] Certain Iguanidae, such as *Anolis carolinensis*, do not have femoral pores, and others, such as *Phrynosoma cornutum*, do not show distinctively enlarged postanal plates in the male.

TABLE I

TABLE SHOWING SEXUAL DIMORPHISM IN CHARACTERS OF *CROTAPHYTUS COLLARIS* (Say)

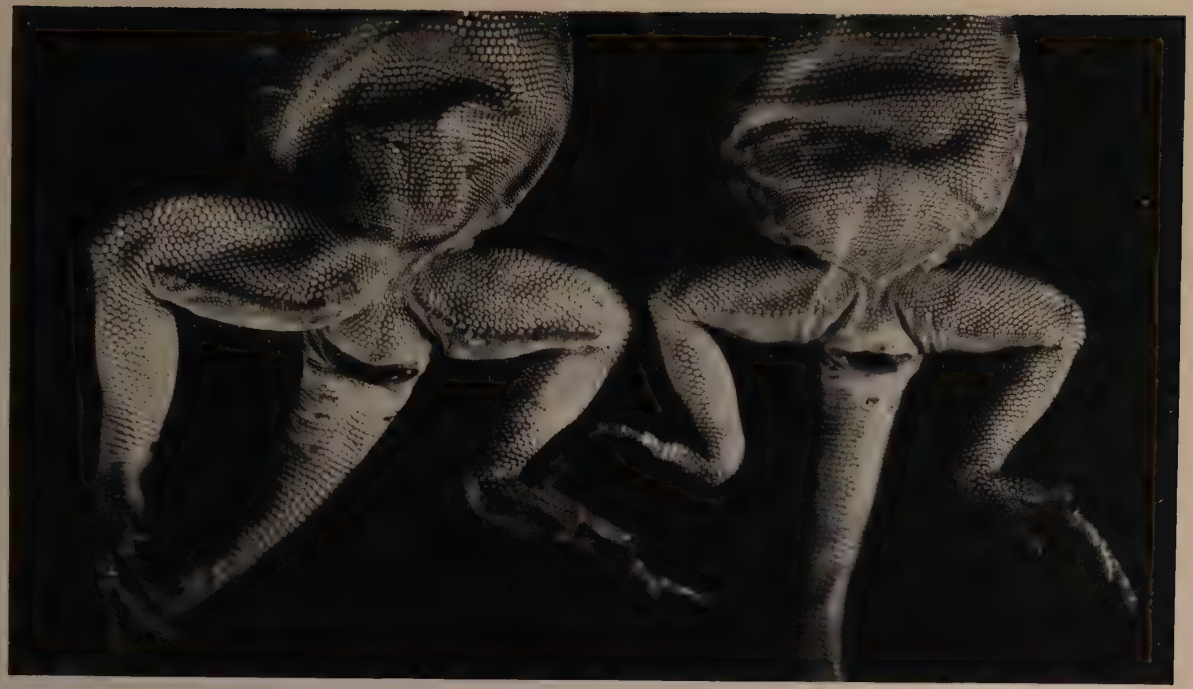
Character (measurements in mm.)	Males		Females		Difference in averages (sexual dimorphism)
	Number of specimens	Average	Number of specimens	Average	
Body length (snout to anus)	659	87.7	597	82.1	5.6 mm.
Tail length	595	171.8	554	154.8	17.0 mm.
Total length	595	257.3	554	236.9	20.4 mm.
Head width	659	21.9	597	19.0	2.9 mm.
Length of hind leg	215	81.5	159	73.1	8.4 mm.
Tail length as percentage of total length.	595	66.3	554	65.3	1.0 per cent
Head width as percentage of body length	659	25.2	597	23.1	2.1 per cent
Length of hind leg as percentage of body length	215	92.2	159	88.5	3.7 per cent
Number of femoral pores	659	17.8	597	17.8	none

This table needs little elaboration. The number of specimens upon which the averages for each sex are based varies for certain characters, partly because of defective or broken tails in many specimens, and partly because the length of the hind leg was not taken during the earlier part of the work. It will be noted that all extremes in length, width, or percentage are found in male specimens only, and that there is no tendency toward the reduction of the number of femoral pores in the females as one might expect from the studies of *Phrynosoma cornutum* and *Sceloporus merriami* cited above.

ACKNOWLEDGMENTS

The writer wishes to take this opportunity to express his appreciation to Dr. Peter O. Okkelberg of the Department of

PLATE XXIII



A ventral view of the anal and femoral regions of two adult specimens of *Crotaphytus collaris* (Say) to illustrate their sexual dimorphism

Male (left). Waterville, Marshall County, Kansas. Univ. Mich. No. 65008
Female (right). Manhattan, Riley County, Kansas. Univ. Mich. No. 65007

Zoölogy of the University of Michigan for kindly criticising this manuscript. To the numerous institutions and individuals who have loaned or given collared lizards to be used in this study much credit is due, since without their aid a large part of these data could not have been obtained.

University of Michigan

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CYCLIC CHANGES IN THE MAMMARY GLAND OF THE MOUSE

LAWRENCE P. COGSWELL

SOME investigators believe that there are growth changes in the mammary glands of the mouse associated with the oestrus cycle, and others have denied it. Consequently various theories have been advanced to account for the different findings. It has been my aim to repeat this work and arrive at a definite conclusion as to the changes in mammary tissue, if any, in the mouse.

In many mammals, including the higher rodents, it has been definitely established by Loeb (1923), Hartman (1923), and others, that during the normal sexual cycle there is a decided growth of mammary tissue before oestrus or ovulation, and subsequent regression during or after the meta-oestrus period. Loeb concludes that in the case of the guinea pig, during pregnancy as well as without pregnancy, the corpus luteum calls forth the growth of the mammary gland.

He also states that a noteworthy growth of mammary tissue except during pregnancy has not been observed in the rat and the mouse, and accounts for this by the lack of a luteum phase in these animals. In other words, as Allen (1923) found: "In mice where ovulation is spontaneous at each oestrus, because of the short cycle (4–6 days) and the persistence of the corpora lutea of oestrus through several cycles, lives of corpora from several successive ovulations overlap. There may be several sets of corpora in the ovaries at one time and still cycles succeed each other regularly." He was further able to show that follicular fluid extracted from sow ovaries produced typical oestrus conditions and growth of mammary gland when injected into the mouse. He concludes that a hormone secreted by the Graafian follicle is responsible for oestrus in the mouse.

Sutter (1921) reports a rapid proliferation of the branches of the mammary ducts in the rat at oestrus, and continued development until near the next pro-oestrus period, when regression occurs, and he accounts for regression as possibly being due to degeneration of the corpora lutea. This, however, does not check up with Allen's findings that the corpora of oestrus persist throughout several cycles.

In my experiment I have used only sexually mature virgin female mice of brown and black stock. The mice were all kept under the same environmental conditions and given a plentiful supply of food. The period of oestrus was determined according to the method of Stockard and Papanicolaou, by examining the cell content of the vaginal fluid. The animals were killed during the four stages of the cycle and whole mounts made of the mammary tissue of each mouse. Of the tissue thus prepared from forty-three mice, I noticed a marked difference in the branchings of the mammary ducts corresponding to the period in which the animal was killed.

Plate XXIV, Figure 1, is a photograph of mammary gland typical of a mouse in the di-oestrus or resting period. It is seen that the branchings of the ducts are few and that they are free from buds.

Plate XXIV, Figure 2, is a photograph of the mammary gland during pro-oestrus, and is not vastly different from the preceding stage, although the branches seem to have given rise to many minute buds.

Plate XXIV, Figure 3, shows the condition during the oestrus period. Many more buds have suddenly appeared, and the ducts have become greatly proliferated.

Plate XXV, Figure 1, shows the gland during the early meta-oestrus period and shows that the gland continues to grow rapidly even after oestrus.

Plate XXV, Figure 2, shows a typical meta-oestrus condition of the mammary gland. The branches are in a greatly proliferated condition.

Plate XXV, Figure 3, shows the gland during the late meta-oestrus period. The branchings have become less definite and

PLATE XXIV

FIG. 1

FIG. 2

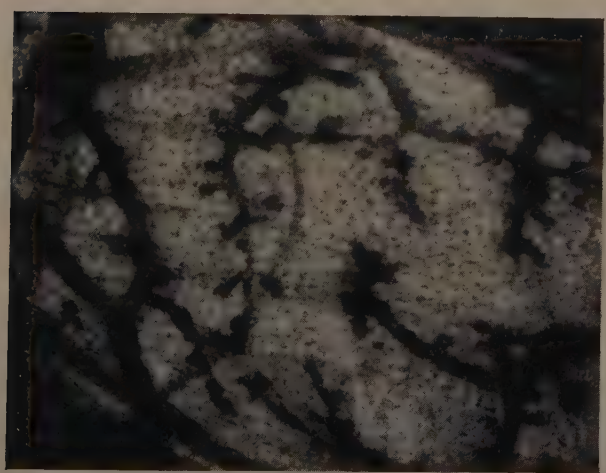

FIG. 3

PLATE XXV

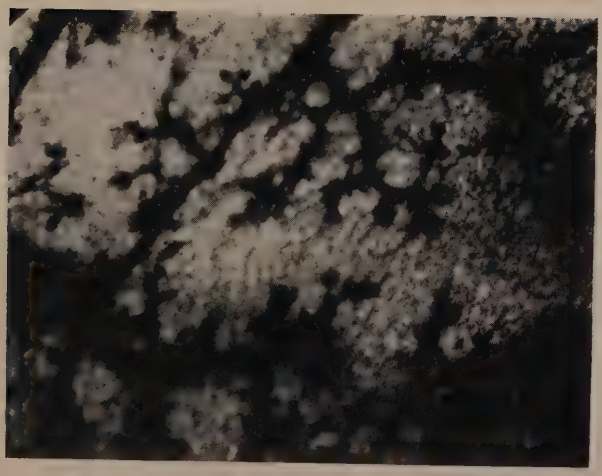

FIG. 1

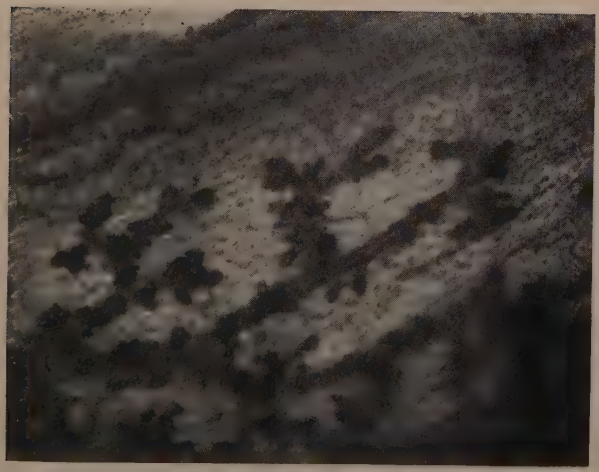

FIG. 2

FIG. 3

the gland is approaching the condition noted in Plate XXIV, completing the cycle.

In these plates, I have not picked extreme cases, but what I have considered to be a fair representative of all those of a given period.

This experiment shows clearly that there is a cyclic change in the mammary gland of the mouse accompanying the oestrus cycle, but leaves in doubt the cause of this change.

Allen and Doisy found that injections of follicular fluid stimulate mammary growth, hence it seems probable that the normal mammary changes described here are, like other oestrus phenomena, caused by a follicular hormone.

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THE FOOD OF YEARLING SMELT FROM MICHIGAN*

CHARLES W. CREASER

THIRTY–ONE yearling smelt (*Osmerus mordax*) were taken by Dr. Carl L. Hubbs in Mountain Lake, Marquette Co., Michigan, with a drag seine along the shore at night, July 6–10, 1927. They were on the average about 72 mm. in length (about 3 inches total length). All were in their second summer, being just past one year old. Considerable growth had taken place since spring. These fishes, however, had not yet reached a size comparable to the first season's growth in Crystal Lake, Michigan, which on the average is almost 100 mm. The size of the Mountain Lake smelt at the end of the first year was determined as 60 mm. from the scales, by a comparison with the scale length, fish length ratio worked out for Crystal Lake smelt. In these smelt by a detailed study not yet published it was found that the growth of the posterior field of the scale over the length here discussed is directly proportional to the growth of the fishes, or so nearly so as to render error negligible. This slow rate of growth may be attributed either to the short growing season or poor food in Mountain Lake, or to the chance that a small race was planted there. The fairly large size of one of the adults taken from the same lake suggests that the first of these conclusions is probably correct.

About thirty-two specimens comprised the collection. Stomachs of twenty-eight were examined and the contents listed for each specimen. The amount of food in each was so small in

* Contribution from the College of the City of Detroit and the University of Michigan Biological Station. This report is supplementary to the writer's paper on "The Establishment of the Atlantic Smelt in the Upper Waters of the Great Lakes," *Papers of the Michigan Academy of Science, Arts and Letters*, Vol. V, 1925 (1926), pp. 405–424, Fig. 25 and Pls. 24–27.

quantity that a volumetric method could not be readily used. However, a rough estimate of the proportion of different food items was made. Four of the stomachs were empty.

Smelt No. 1, 70 mm. A full stomach; the contents chiefly of free-swimming Copepoda, many Cladocera, one Chironomus, and one pupa of some small insect.

No. 2, 70 mm. A full stomach, containing only fishes — two smelt fry.

No. 3, 71 mm. A full stomach; the contents, one fish.

No. 4, 71 mm. Not a full stomach; contained one insect, several Copepoda and some remains of Crustacea.

No. 5, 75 mm. A full stomach; the contents, many Copepoda.

No. 6, 72 mm. Stomach contents, 90 per cent one smelt fry, and the remainder Copepoda.

No. 7, 77 mm. Stomach contents, many Copepoda and one very small insect nymph.

No. 8, 72 mm. Stomach full of Copepoda.

No. 9, 71 mm. Stomach contents, many Copepoda and the remains of an insect.

No. 10, 74 mm. Stomach empty.

No. 11, 80 mm. Stomach empty.

No. 12, 72 mm. A full stomach; the contents, four small fishes.

No. 13, 71 mm. Stomach entirely filled with Copepoda.

No. 14, 70 mm. Stomach empty.

No. 15, 70 mm. A full stomach, containing many Copepoda and one insect larva.

No. 16, 72 mm. A full stomach, with one young fish.

No. 17, 74 mm. Stomach filled with one young fish.

No. 18, 71 mm. A full stomach, holding many Copepoda and two midge larvae.

No. 19, 71 mm. Stomach almost empty; the contents one insect larva and a few Copepoda.

No. 20, 71 mm. Stomach almost empty, having very few Copepoda.

No. 21, 71 mm. Stomach almost empty; only a few Copepoda evident.

No. 22, 72 mm. Stomach very well filled with one young fish.
No. 23, 71 mm. Stomach full; the contents, many Copepoda and one insect larva.
No. 24, 71 mm. Stomach about empty; a few Copepoda and one insect larva remaining.
No. 25, Stomach filled with three young fishes and many Copepoda.
No. 26, 66 mm. Stomach empty.
No. 27, 67 mm. Stomach only partly filled with Copepoda and other crustacean remains.
No. 28, 71 mm. The stomach contents consisted of the remains (wings, body) of adult insects, and Cladocera.
No. (?). One fish spewed up and found in jar, probably the entire contents of one of the empty stomachs of this list.

SUMMARY

28 stomachs examined:
7 full stomachs contained only fishes.
2 full stomachs; about 90 per cent of contents fishes, the remainder Copepoda.
9 full stomachs were filled with Copepoda.
7 almost empty, contained a few Copepoda or adult insects, etc.
3 empty.

The fishes from the stomachs were examined and with the aid of Dr. Hubbs determined as 8 smelt fry (*Osmerus mordax*) and 8 perch fry (*Perca flavescens*).

It will be noticed from the tabulation that of the 25 stomachs with food, 9 contained fishes. Since in most cases these fishes made up about 100 per cent of the stomach contents and only 18 stomachs were filled, about 47 per cent of the food of these young smelt is composed of young fishes divided about equally between perch and smelt fry. About an equal quantity consists of Copepoda. The remainder is composed of insect larvae or adults. In this respect it may be noted that even in early life the smelt may be a formidable enemy of other fishes. Since only its own fry and the fry of game fishes largely comprise

the young fish fauna of Mountain Lake, the introduction of the smelt into this lake as a source of food for the game fishes seems to have been unwise. It appears, however, that the smelt have not become common in this lake, since only one adult was taken in a considerable number of gill-net sets. Furthermore, since the Copepoda presumably furnished food for the young of the game fishes, in this respect the smelt is a competitor, but very probably this is not a serious matter, because of the great abundance of such food.

The one adult smelt taken in Mountain Lake contained in its stomach several each of midge pupæ (*Corethra*) and amphipod crustaceans (*Pontoporeia*). It was, therefore, competing with the small race of lake herring (*Leucichthys artedi*) inhabiting this lake, which was found to be feeding on the Corethra in addition to Entomostraca (and also to a slight extent on insects). This may be a point of considerable importance, since the lake herring form the natural and chief food of lake trout in Mountain Lake.

W. C. Kendall[1] states that "Young smelts, like many other young fishes, subsist upon the minute floating animal life known to the scientific man as plankton," and reports Professor Doolittle as finding that young smelt fry recovered from the stomachs of brook trout from Sundpee Lake had been feeding upon Entomostraca.

In lakes like Mountain Lake, containing large numbers of lake trout or other salmonoids, the wisdom of planting smelt as a source of food for the game fishes may for the reasons just assigned be seriously questioned. It is certain that the smelt in many lakes of the non-salmonoid type is not a favorable substitute for a minnow fauna, the chief economic value of which is the conversion of small invertebrates and plants into food for the economically desirable predaceous fishes. Its ability to maintain itself on either the crustacean food or young fishes and its more freely swimming habits give it a broader sweep of the lake, and tend to favor it against fishes which are largely confined to either the one or the other of these types of food, and

[1] *Bulletin of the Bureau of Fisheries*, Vol. XLII (Bureau of Fisheries Document No. 1015), Washington, D. C., pp. 281, 287.

to shore waters. Except where the spring run and ice fishing can be utilized and controlled without jeopardy to other species, there is nothing to be gained by planting smelt. If a lake of this type is in need of fishes as a fish food, some species of minnow or sucker would probably be far more favorable for stocking.

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THE FOOD OF LARVAL LAMPREYS*

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THE food of larval lampreys has received but little attention. References in the literature contain only generalized statements. Gage (1893) states that "the food of the larva consists of microscopic organisms." The structure of the mouth is such as to make such a feeding habit necessary. In the present paper we wish to present a detailed study of the stomach contents of of these larvae at a series of sizes.

Several of the brook species of lamprey feed only during the larval or ammocoetes stage, the adult being without a functional digestive system. These species are derived from the blood-sucking, flesh-rasping type with short larval periods. Each parasitic type has developed a neoteinic derivative having a tendency to relegate all the functions of life to the larval stage, retaining only reproductive functions in the adults (Creaser and Hubbs, 1922; Hubbs, 1924). The food of these degenerate types is therefore of much interest. Some insight into the feeding habits of these larvae was also obtained by this study.

It is well known that the larvae of our non-parasitic brook lampreys lead a fossorial existence (Gage, 1893), burrowing in the recently deposited alluvium and mud of streams. It is possible to collect them in great quantity by shoveling up this deposit, throwing it on the bank of the stream, and sorting it with the hands. Any specimen overlooked will later wriggle its way to the surface as the mud begins to drain free of moisture.

The specimens used in the present study were obtained by the method described above from the Big Pigeon River ten miles east of the village of Wolverine, Cheboygan Co., Michigan, July 10, 1926. Two specimens from the Maple River are also

* Contribution from the University of Michigan Biological Station.

listed. As the specimens were collected, they were placed immediately in 5 per cent formalin which stopped digestion, leaving the stomach contents very well preserved. The specimens studied were all of the species *Entosphenus appendix* De Kay, which is abundant throughout Michigan.

A second trip was made on August 2, 1926, to the same locality on the Big Pigeon River and samples were taken of the surface water, the material on the top of the mud of the bottom, and that buried within the bottom material itself. The samples from the surface water were taken by means of a number twenty silk bolting cloth, cone plankton net. The source of the food material was in this way easily ascertained. Most of the determinations were made with the aid of *Fresh-Water Biology*, by Ward and Whipple (1918).

The stomach contents of ammocoetes of *Entosphenus appendix* from Big Pigeon River ten miles east of Wolverine, Cheboygan Co., Michigan, July 10, 1926 were as follows:

Specimen No. 1, size 119 mm. *Merismopedia, Closterium, Scenedesmus, Cocconema, Synedra, Staurastrum, Xanthidium, Botryococcus, Diatoma*, filamentous green algae, pine pollen, quartz crystals.

No. 2, 115 mm. *Meridion, Amphora, Navicula, Merismopedia, Staroneis, Synedra, Cocconema, Scenedesmus, Closterium, Cymbella*, filamentous green algae, desmid, pollen, quartz crystals.

No. 3, 90 mm. *Botryococcus, Navicula, Amphora, Scenedesmus, Closterium, Synedra, Pediastrum, Arthrodesmus, Chroöcoccus*, filamentous algae, *Cocconeis*, quartz crystals.

No. 4, 120 mm. *Synedra, Navicula, Scenedesmus, Closterium, Merismopedia, Meridion, Cocconema, Pleurosigma, Pediastrum, Cocconeis*, filamentous algae, quartz crystals.

No. 5, 119 mm. *Navicula, Scenedesmus, Fragilaria, Amphora, Synedra, Meridion, Closterium*, filament of blue-green algae, quartz crystals.

No. 6, 121 mm. *Meridion, Navicula, Synedra, Amphora, Scenedesmus, Closterium, Cocconema*, quartz, *Merismopedia, Fra-*

gilaria, Phacus, Cocconeis, pine pollen, *Pediastrum, Coelastrum, Staurastrum, Tabellaria.*

No. 7, 111 mm. *Navicula, Scenedesmus, Meridion, Amphora, Closterium, Fragilaria, Merismopedia, Cymbella, Synedra, Cocconeis, Asterionella,* filament of blue-green algae, *Tabellaria,* quartz crystals.

No. 8, 65 mm. *Synedra, Scenedesmus, Navicula, Closterium, Amphora, Coelastrum, Meridion, Fragilaria, Cocconeis,* quartz crystals.

No. 9, 39 mm. *Scenedesmus, Synedra, Navicula, Amphora, Closterium, Merismopedium, Cocconema,* quartz crystals.

No. 10, 74 mm. Filamentous blue-green algae, *Scenedesmus, Amphora, Closterium, Synedra, Merismopedia, Meridion, Navicula, Phacus, Staurastrum,* quartz crystals.

No. 11, 121 mm. *Meridion, Cocconema, Merismopedia, Scenedesmus, Navicula, Synedra, Amphora, Fragilaria,* filamentous green algae, unicellular algae, quartz crystals.

No. 12, 111 mm. *Meridion, Cocconema, Scenedesmus, Fragilaria, Navicula, Amphora, Cocconeis, Synedra, Closterium,* quartz.

No. 13, 114 mm. *Meridion, Scenedesmus, Amphora, Closterium, Fragilaria, Merismopedia, Synedra, Navicula, Surirella, Pinnularia,* unicellular algae, quartz crystals.

Specimens Nos. 14 and 15 were collected from Maple River, east of Brutus, Michigan, July 15, 1926.

No. 14, 91 mm. *Fragilaria, Meridion, Navicula, Amphora, Cocconeis, Synedra, Scenedesmus, Closterium, Staurastrum, Merismopedia,* quartz crystals.

No. 15, 42 mm. *Navicula, Amphora, Fragilaria, Cocconeis,* filamentous green algae, *Meridion, Scenedesmus, Closterium, Staurastrum,* quartz crystals.

Samples taken from Pigeon River, August 2, 1926, contained the organisms listed below.

Surface sample. *Cocconema, Cocconeis, Scenedesmus, Navicula, Amphora,* pine pollen, *Anuraea, Rattulus, Cladocera, Merismopedia, Synedra, Pediastra,* filamentous green algae.

Sample from ooze from top of sand. *Scenedesmus*, filamentous green algae, *Navicula*, *Closterium*, *Amphora*, *Cocconema*, *Synedra*, *Merismopedia*, *Meridion*, *Cocconeis*, *Pinnularia*.
Sand sample. Empty frustules of *Navicula* and *Cocconeis*.

GENERAL CONCLUSIONS

Specimens of Cyanophyceae and Chlorophyceae were present within the digestive tracts of all specimens examined.

The kinds of algae most prevalent were diatoms and desmids. In many of the desmids the color of the cell contents was natural and unchanged. Two specimens showed the presence of Protozoa (Phacus). Protozoa no doubt form a generous proportion of the food, but are so quickly digested that few can be identified in the stomach contents. Sand crystals were present in all the stomachs.

The water surface samples contained practically all the material found within the digestive tracts of the ammocoetes. The thin layers of sediment and detritus deposited upon the sand or rolling with the current contained the same organisms in great abundance. The color in some of the desmids was that of normal living organisms. The sand contained only a few empty shells of diatoms.

It is evident that the food of the larvae of lampreys comes from the water of the stream and the sediment and detritus which develop or settle out on the quiet parts of the bottom. None of the food comes from the stream bed material even though the larvae burrow into this. The construction of an open burrow by these larvae is probably a part of the process of obtaining food from the bottom material.

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FISHES OF NORTH DAKOTA

THOMAS L. HANKINSON

DURING the last few years efforts have been made to study the species of fishes of North Dakota, to learn what species occur in the state and something of their distribution, ecological relations, and economic status. It is evident from the brief survey upon which this paper is based, comprising less than two months of field-work, that systematic field-studies of the fishes of North Dakota should be continued in a more extensive and comprehensive way.

In this paper there is included, in addition to the results of collecting expeditions, all useful and authentic published information on North Dakota fishes that could be found by an examination of scientific literature. The publications examined are listed in the bibliography at the end of this paper. An attempt is thus made to indicate the status of North Dakota ichthyology at the present time.

The survey on which this paper is based began in 1921, when Dr. R. T. Young, then of the University of North Dakota, obtained collections from about thirty localities in the state. His collections contained sixteen species. In the summer of 1922 the coöperative biological survey by the University of North Dakota Biological Station and the Museum of Zoölogy of the University of Michigan, under the immediate direction of Miss Crystal Thompson, took up the study of the fish of the state. The writer was given charge of the field-work and, with the help of Mr. Robert Johnstone of the Biological Station, collected in the lakes of the Devils Lake region, in the Turtle Mountains, and in streams of the Red and James River systems. In June, 1926, many collections were made from the streams of the Red and the Missouri systems by Carl L. Hubbs and Leonard P.

Schultz, while they crossed the state on an expedition to the Pacific Coast.

The collections from all these expeditions were studied by the writer with valuable and considerable help from Dr. Hubbs. The specimens have been deposited in the Museum of Zoölogy, Ann Arbor.

The only ichthyological survey of the waters of North Dakota previous to ours was the one made by Woolman in July and August, 1892 (Woolman, 1896). His paper also deals with the fauna of the Red River system in Minnesota. The more significant of his Minnesota records are mentioned in the present paper, although the Minnesota streams of this system appear to be very different from those of North Dakota, being ordinarily clearer, with bottoms of sand rather than mud. Fish in these streams may, therefore, not occur in North Dakota for ecological reasons, although the streams might be freely entered by them. These Minnesota localities examined by Woolman are Red Lake, Red River Lake, Buffalo River at Hawley, and Otter Tail Creek at Breckenridge. Woolman's records from Moorhead may properly be included as North Dakota records, since this place is on the Red River bordering North Dakota. The species of fish noted for the Red River at Winnipeg, Canada, by Eigenmann (1894) and by Evermann and Goldsborough (1907) and by Ernest Seton Thompson (1898) for the Souris and the Red rivers in Manitoba are also included in this report. Evermann and Cox (1896) in their account of the fishes of the Missouri system mention some occurrences of fish in North Dakota, and their records for the James River in South Dakota are important in the present consideration and are all given in the annotated list. A few records found in the publications on fish of Minnesota by Cox (1897) and Surber (1920), which have a bearing on North Dakota fish studies, are also included.

The kinds of waters that have been examined during these fish investigations in North Dakota were streams, lakes and coulées. The latter were once streams, but owing principally to the recession of lake waters with which they were connected, they have become elongated ponds called coulées. Two of these

of special interest in our work were the Mauvaise (Pl. XXVIII, Fig. 3) and the English coulées. The former was once a large stream connected with Devils Lake.

The streams visited were principally those of the Red and the Missouri River systems. The only contributions from the Mouse or Souris River system in North Dakota are those by Woolman (1896) and a few collections by the writer in Willow Creek near Bottineau. Since the Mouse River is a rather direct tributary to Hudson Bay, its fish are likely to prove of special interest. No collections were made from the Missouri itself, but fish were taken from the following tributaries: Little Missouri at Marmarth (Pl. XXVII, Fig. 4) and Medora, Heart (Pl. XXVII, Fig. 3), Cedar, Cannon Ball, Curlew, James (Pl. XXVII, Fig. 1) with its branch the Pipestone Creek (Pl. XXVII, Fig. 2) at Jamestown and the main stream at La Moure, Apple Creek at Bismarck, and Sweet Briar Creek at Mandan. The water of all these streams was turbid and the bottom was largely clay, with sand and gravel in the more rapid parts. Since shallow areas permitting wading were usually extensive, seining was easy, except in the swift waters of the larger streams. Aquatic vegetation was ordinarily scant. In some places, as at Jamestown, the banks were wooded (Pl. XXVII, Fig. 1), but commonly the streams wound through open prairie (Pl. XXVII, Fig. 3).

The Red River was found to be sluggish and turbid, varying considerably in width, while at Fargo and at Pembina (Pl. XXVI, Figs. 1–2), it was sixty to a hundred feet wide. The bottom along the margin everywhere visited was of soft clay making wading and hence seining difficult or even impossible in places. Out from the shore, however, the bottom was commonly firm and the water shallow, and seine hauls were readily made. Visible aquatic vegetation was absent except for a few patches of ditch grass (*Ruppia maritima*).

Fish have been collected and studied from the following streams of the Red River system: Pembina, Forest, Park, Goose, and Sheyenne rivers in North Dakota, and from Buffalo, Red Lake, and Otter Tail rivers in Minnesota. The Sheyenne, the largest of these streams, was fished near Pekin (Pl. XXVI, Fig. 3), at

Lisbon (Pl. XXVI, Fig. 4), and at Valley City and was found to have an abundant and varied fish population. It is a beautifully winding river in its upper course with a succession of pools and riffles and is ordinarily about twenty to thirty feet wide. The bottom is firm and gravelly, and the water turbid. Rank growths of submerged aquatic plants, such as stonewort (Chara?), hornwort (Ceratophyllum), and water weed (Anacharis) were frequent. Water bugs (notonectids and corisids) were abundant, and many small mussels were present in the bottom material.

The North Dakota lakes examined were those of the Drift Prairie Plain, which is the extensive level or, in places, gently rolling region between the valley of the Red River and the Missouri River region, and the lakes of the group of forested hills known as the Turtle Mountains (Pl. XXIX, Fig. 3).

Devils Lake and other lakes in its vicinity were given most attention. Those examined were Devils (Pl. XXVIII, Fig. 1), Sweetwater, Irwin, Irvine, Stump, Fort Totten, and Free Peoples. Of the many lakes of the Drift Prairie Plain remote from Devils Lake, collections were made from the following: Strawberry near Ruso, Spiritwood (Pl. XXVIII, Fig. 4), Arrow Wood, Buffalo, Alkaline, Juanita, Williams, Isabelle, Ensign, Red Willow (Pl. XXIX, Fig. 2), Wood (Pl. XXIX, Fig. 1), Brush, Etta, Jim, and Painted Woods. In the Turtle Mountains the following lakes were visited and collections made from them: Fish, Belcourt (Pl. XXIX, Fig. 4), Carpenter, Dion, Jarvis, Gordon, Metagoshe, Yravell, and, close by these mountains, Dunseith Lake.

Some lakes of the Drift Prairie Plains have wooded shores, but for the most part they lie in open prairie bordered by broad, low beaches often whitened with saline deposits (Pl. XXVIII, Fig. 2). In form and size they differ greatly: many are half a mile long, while the largest, Devils Lake, is nearly thirty miles in length. They are ordinarily shallow, with a maximum depth of less than twenty feet. The water comes from surface run-off and springs. The amount of water fluctuates considerably from year to year, and most of them, like Devils Lake, appear to be gradually drying up. Ordinarily there are no outlet or inlet streams. The salt content of the waters is large and quite vari-

FIG. 1. Red River of the North at Pembina, North Dakota

FIG. 3. Sheyenne River near Pekin, North Dakota

FIG. 2. Red River of the North at Fargo, North Dakota

FIG. 4. Sheyenne River at Lisbon, North Dakota

FIG. 1. James River at Jamestown, North Dakota

FIG. 3. Heart River, North Dakota.
Photograph by Leonard P. Schultz

FIG. 2. Pipestone Creek, Jamestown, North Dakota

FIG. 4. Valley of the Little Missouri River at Marmarth, North Dakota. Photograph by Leonard P. Schultz

FIG. 1. Devils Lake, North Dakota. An alkaline lake

FIG. 2. Lake Irvine, near Church's Ferry, North Dakota

FIG. 3. Mauvaise Coulée, near Devils Lake, North Dakota

FIG. 4. Spiritwood Lake, north of Jamestown, North Dakota

FIG. 1. Wood Lake, near Tokio, North Dakota.
A fresh water lake with good fishing

FIG. 3. Turtle Mountain region. General view

FIG. 2. Red Willow Lake, north of Cooperstown,
North Dakota

FIG. 4. Belcourt Lake, Turtle Mountain, North Dakota

able in amount, so that it has been possible to classify them into "fresh-water," "intermediate," and "alkaline" lakes (Young, 1923 a). Important "fresh-water" lakes, those having alkalinity under 400 parts per million (Young, 1923 a, p. 388), are Arrow Wood, Jim, Fourth, Ensign, Fort Totten, Juanita, Painted Woods, Red Willow, Spiritwood, Strawberry, Wood, and the lakes of the Turtle Mountains. Intermediate lakes, with alkalinity ranging from 400 to 700 p.p.m., are Brush, Sweetwater, South Free Peoples, and Williams. The alkaline lakes, with alkalinity above 700 p.p.m., are Devils, Stump, Buffalo, Etta, North Free Peoples, and Isabelle. Results of chemical analyses of North Dakota lakes are given by Pope (1908, p. 14), Edmondson (1920, p. 169), Young (1923, p. 389; 1924, p. 28), and Abbott (1925, p. 182).

Aquatic vegetation was sometimes abundant and sometimes scant in these lakes of North Dakota. The most abundant and prominent water plant was the ditch grass (*Ruppia maritima*). This formed a rank zonal growth in Devils Lake (Young, 1924, p. 74) and in most of the others often formed a dense mat extending to the surface. The shore vegetation was ordinarily complex with shrubs and a varied herbage, with rushes and sedges commonly prominent.

There appeared to be an abundance of invertebrates in all the lakes examined (Young, 1924, on Devils Lake). Water boatmen (Corixidae) were numerous in most shallow lake waters, and an amphipod (*Hyallela*) occurred locally in large numbers; a pint or more of them were in every seine haul we made at Fish Lake. Here was an instance of a great abundance of fish food with very few fishes to make use of it.

Aquatic vertebrates other than fish were observed incidentally and, hence, incompletely while we were making field-studies and collections of fish. Many water birds were seen and listed, but a consideration of them will be omitted in view of the abundant literature on the subject, including the recent and valuable ornithological papers by Wood (1923) and Williams (1926). Reptile life was little in evidence. A few garter snakes (*Thamnophis*) were seen on lake and stream shores. Turtles

appeared rare, and only a few painted turtles (*Chrysemys*) were seen. Frogs (principally *Rana pipiens*) were common shore-dwellers. In many of the lakes gilled larvae of the tiger salamander (*Ambystoma tigrinum*) were abundant and often of large size — six or eight inches or more in length. This is undoubtedly the salamander that has been erroneously named *Cryptobranchus alleghaniensis* in some early publications on North Dakota life.

Not many animals were noted about the North Dakota waters visited that could be considered important enemies of fish. Most of the water birds that are so numerous in the region were found to be species that feed upon insects and vegetation. A few blue herons (*Ardea herodius herodius*) were seen and a large colony of black-crowned night herons (*Nycticorax nycticorax naevius*) was found near a lake in the Turtle Mountains. Kingfishers (*Ceryle alcyon*) were present in the vicinity of shallow waters where there were small fish in abundance; and their rattle gave us clews for finding good places for fish specimens.

In the course of the fish survey outlined above, not only were collections made, but notes were also taken on all conditions in a body of water affecting its fish life, such as nature and abundance of vegetation, character of water and bottom, depths, temperatures, and animals associated with fish, that might be ecologically related to them as food or enemies. In some lakes or streams, many fish were seen or reported that were not collected; these were noted also in the attempt to find what species were present, their proportionate numbers, behavior and interrelations. All such data are preserved and may be useful if, in the future, a more intensive ecological study of North Dakota fishes is made.

Collecting was done principally with "common sense" minnow seines of six and twenty-five foot lengths, used in water of less than about four feet deep. In the future intensive studies of those lakes in which fish thrive should be made, with facilities for investigating the deep waters, and the studies should be made at all seasons. The extent of winter killing of fish and the methods of avoiding such mortality should be investigated. The studies initiated by Dr. R. T. Young on the acclimatization

of food and game fish to alkaline waters of North Dakota lakes, which have other conditions favorable for a large population of useful species, should be continued.

The writer wishes to acknowledge important services in preparing this report and obtaining material for it. Thanks are due to Miss Crystal Thompson, who helped plan the field program and assisted with some of the collecting; to Dr. Carl L. Hubbs, who went over the collections with the writer and examined the manuscript, and, with Mr. Leonard P. Schultz, obtained many of the fish specimens; to Dr. R. T. Young, who furnished the writer with publications useful in the work and sent some collections and made some valuable suggestions by mail; and to Mr. Robert Johnstone, who helped with the collecting and attended to the transportation and many important details of the collecting trips. We thank the North Dakota Game and Fish Commission for issuing permits for taking fish, and the Great Northern and the Canadian Pacific railways for giving considerable free transportation for our party and equipment.

ANNOTATED LIST

1. Ichthyomyzon concolor (Kirtland). Silvery Lamprey. — Red River, reported by Dr. R. T. Young as *Petromyzon castaneus* (Brannon, 1912, p. 21); Sheyenne River at Lisbon as *Ammocoetes branchialis* (Woolman, 1896); Red River in Minnesota (Surber, 1920; Cox, 1897). Young noted its presence in sufficient numbers in the Red River to be a dangerous enemy of the few food fish found there.
2. Scaphirhynchus platorhynchus (Rafinesque). Shovelnose Sturgeon. — Missouri River, Buford, N. D. (Jordan, 1878).
3. Amphiodon alosoides Rafinesque. Goldeye. — Red River. at Pembina (Hankinson); Red River (Woolman, 1896); Red River, by R. T. Young (Brannon, 1912, p. 21); Red River at Winnipeg (Eigenmann, 1894); Little Missouri (Hubbs and Schultz).
4. Hiodon tergisus Le Sueur. Moon Eye. — Red River at Grand Forks and throughout the Red River Basin (Wool-

man, 1896); Red River at Winnipeg (Eigenmann, 1894); Red Lake River of Minnesota (Surber, 1920).

5. Carpiodes carpio (Rafinesque). Carp Sucker. — Little Missouri and Heart rivers (Hubbs and Schultz).
6. Catostomus commersonii (Lacépède). Common Sucker. — Sheyenne, and Park rivers and Pipestone Creek (Hankinson); Maple, Sheyenne, Curlew, Heart, Cannon Ball, Cedar, James, and Little Missouri rivers (Hubbs and Schultz); Strawberry Lake at Ruso, Spiritwood Lake, and Sheyenne River (R. T. Young); Souris River (Thompson, 1898); Pembina, Park, Maple, James, Mouse or Souris rivers, English Coulée at Grand Forks (Woolman, 1896); Red River by Young (Brannon, 1912, p. 21); Sheyenne River (Pope, 1908). Woolman notes this sucker very abundant in the James River at La Moure. In North Dakota examples of this species there is considerable diversity in the number of rows of papillae on the lips; a variation toward the subspecies *sucklii* is thus indicated. The species is abundant in North Dakota and apparently is very generally distributed there. The young inhabit stream shallows and the adults the deep stream waters in the summer. The species also occurs in lakes of low salinity.
7. Erimyzon sucetta oblongus (Mitchill). Chub Sucker. — Sheyenne River at Lisbon, only one taken (Hankinson).
8. Moxostoma lesueurii (Richardson). Northern Red-horse. — Red and Sheyenne rivers (Hankinson); Heart and Cannon Ball rivers (Hubbs and Schultz); Red, Park, Sheyenne, James rivers as *Moxostoma macrolepidotum duquesnii* (Woolman, 1896); Jamestown, N. D., as *M. m. duquesnii* (Evermann and Cox, 1896).
9. Cyprinus carpio Linnaeus. European Carp. — Heart, Cedar, Cannon Ball, and Little Missouri rivers (Hubbs and Schultz).
10. Platygobio gracilis (Richardson). Flat-headed Chub. — Little Missouri River at Marmarth and Medora; very abundant (Hankinson); Little Missouri at Marmarth and in the Heart, Cedar, and Cannon Ball (Hubbs and Schultz).

11. Macrhybopsis gelidus (Richardson). — Little Missouri River; four taken (Hubbs and Schultz). Dr. Hubbs informs the writer that this species is common in the tributaries of the Missouri in Montana.
12. Nocomis biguttatus (Kirtland). River Chub. — Red, James rivers, Buffalo River in Minnesota, Pipestone Creek at Jamestown, N. D.; common here as well as in the James River (Woolman, 1896). Woolman gives the name as *Hybopsis kentuckiensis* (Rafinesque), which is presumably *N. biguttatus*.
13. Erinemus storerianus (Kirtland). Storer Chub. — Red, Pembina rivers (Hankinson); Red River and tributaries (Woolman, 1896); Red River system, Red River at Grand Forks (Cox, 1897); Red River at Winnipeg (Eigenmann, 1894). Woolman reports it common and large in the Red River, often reaching a length of four inches.
14. Rhinichthys atronasus lunatus Cope. Black-nosed Dace. — Red, Park, James rivers, Pipestone Creek (Hankinson); Sheyenne and James (Hubbs and Schultz); James, preferring cool, swift waters (Woolman, 1896).
15. Rhinichthys cataractae (Cuvier and Valenciennes). Long-nosed Dace. — Red, Pembina, Park, Sheyenne, Little Missouri rivers (Hankinson); Heart and Little Missouri (Hubbs and Schultz); Pembina, Forest, Maple, Sheyenne (Woolman, 1896).
16. Semotilus artromaculatus (Mitchill). Creek Chub or Horned Dace. — Red, Pembina, Park, Sheyenne, James, rivers and Pipestone Creek (Hankinson); Sheyenne, James, Heart, Cedar rivers and Apple Creek (Hubbs and Schultz); Red River system of Minnesota and Pipestone Creek, Jamestown, N. D. (Woolman, 1896); an abundant and very generally distributed species in streams of North Dakota. None was found in any of our lake or coulée collections.
17. Margariscus margarita nachtriebi (Cox). Northern Dace. — Belcourt Lake, abundant (Hankinson); Curlew River (Hubbs and Schultz); Strawberry Lake, Ruso (Young). The species is locally abundant in North Dakota waters.

Surber (1920) notes it as locally common in Minnesota lakes.

18. Notropis anogenus Forbes. Pug-nose Shiner. — A specimen found by Hubbs in a collection of black-nose shiners made by Woolman from the Sheyenne River, Lisbon, N. D.; now in the Museum of Zoölogy at Ann Arbor.
19. Notropis heterolepis Eigenmann and Eigenmann. Black-nose Shiner. — Pipestone Creek, Jamestown (Hankinson); Sheyenne and James rivers (Hubbs and Schultz); James, Maple, Sheyenne rivers as *Notropis cayuga* (Woolman, 1896); very probably this species.
20. Notropis deliciosus missouriensis (Cope). Southwestern Straw-colored Minnow. — Red, Pembina, Sheyenne, James rivers, Pipestone Creek, Dunseith Lake (Hankinson); Heart, Cedar, Cannon Ball, James, Little Missouri rivers (Hubbs and Schultz); Pembina, Forest, Sheyenne, Mouse rivers (Woolman, 1896); Red River at Winnipeg (Eigenmann, 1894). An abundant and generally distributed species in North Dakota.
21. Notropis dorsalis (Agassiz). Gilbert Minnow. — Pembina River, a few specimens taken by Hankinson.
22. Notropis blennius (Girard). — Red and Pembina rivers (Hankinson), abundant; Pembina, Forest, Red River tributaries in Minnesota as *Notropis jejunus* (Woolman, 1896); Red River at Winnipeg (Eigenmann, 1894).
23. Notropis hudsonius hudsonius (Clinton). Spot-tail Minnow. — Red, Sheyenne, and James rivers (Hankinson); Sheyenne (Hubbs and Schultz); Spiritwood Lake (R. T. Young); Sheyenne, Park, Mouse rivers (Woolman, 1896); James River at Mitchill, S. D. (Evermann and Cox, 1896).
24. Notropis whipplii Girard. Silverfin Minnow. — Sheyenne River at Lisbon; few taken (Hankinson); Sheyenne River (Woolman, 1896).
25. Notropis rubrifrons (Cope). Rosy-faced Minnow. — Red River at Grand Forks and in Minnesota tributaries of the Red as *Notropis dilectus* (Girard) (Woolman, 1896).
26. Notropis atherinoides Rafinesque. Lake Shiner. — Red

and Pembina rivers (Hankinson); Heart, Cannon Ball, and Cedar rivers (Hubbs and Schultz); Pembina River (Woolman, 1896). Red River system in Minnesota (Surber, 1920); Red River at Winnipeg (Eigenmann, 1894).

27. Notropis cornutus (Mitchill). Common Shiner. — Park, Sheyenne, and James rivers (Hankinson); James River (Hubbs and Schultz); Red, Sheyenne, Maple, Forest, Goose, James rivers, English Coulée at Grand Forks (Woolman, 1896). Abundant and generally distributed in streams. Specimens from the James were typical of the subspecies *frontalis*, but others seemed to be mostly intermediate between this subspecies and *chrysocephalus*.
28. Notemigonus crysoleucas crysoleucas (Mitchill). Golden Shiner. — James River; only two taken (Hubbs and Schultz); Sheyenne River at Lisbon (Woolmann, 1896). Apparently very scarce although coulées and other quiet waters with abundant vegetation seem to produce suitable habitats for the species.
29. Hybognathus nuchalis Agassiz. Silvery Minnow. — Little Missouri, Heart, Curlew, James, Cannon Ball, Cedar rivers, Apple Creek (Hubbs and Schultz). Found by us only in the Missouri system.
30. Hybognathus placitus Girard. — Heart and Cannon Ball (Hubbs and Schultz); Little Missouri (Hankinson).
31. Hybognathus hankinsoni Hubbs (Ms.). — Cannon Ball, Curlew, James rivers, Sweet Briar, and Apple creeks (Hubbs and Schultz).
32. Chrosomus erythrogaster Rafinesque. Red-bellied Dace. — Curlew River and Apple Creek (Hubbs and Schultz). It was found associated, as it commonly is elsewhere, with a rank growth of aquatic vegetation.
33. Hyborhynchus notatus (Rafinesque). Blunt-nosed Minnow. — Sheyenne River (Hankinson); Sheyenne, James, Goose rivers, English Coulée at Grand Forks, and tributaries of the Red River in Minnesota (Woolman, 1896). Apparently uncommon in North Dakota waters at the present time.

34. PIMEPHALES PROMELAS PROMELAS Rafinesque. Black-head Minnow. — Sweetwater, Irwin, Irvine, Court, Wood, Belcourt, Fish, Dion, Carpenter, Gordon, Metagoshe, Dunseith, Spiritwood lakes, English, Mauvaise coulées, Red, Pembina, Park, James, and Little Missouri rivers, Willow and Pipestone creeks (Hankinson); Little Missouri, Curlew, Cedar, James, Heart, and Cannon Ball rivers, ditch near Fargo, pond near Hettinger, Apple and Sweet Briar creeks (Hubbs and Schultz); Ensign, Gordon, Strawberry, Arrow Wood, Williams, Juanita, Fish, Dunseith, Dion, Jim, Etta, Brush, Court, Isabella, Metagoshe, Wood, and Yravell lakes (R. T. Young); Sheyenne, James, and Goose rivers (Woolman, 1896); "common everywhere in lakes and streams in Minnesota" (Surber, 1920, p. 34); Red River at Winnipeg (Eigenmann, 1894). James River at Mitchill, S. D. (Evermann and Cox, 1896). The "minnow" of Devils Lake referred to by Lord (84, p. 351) is undoubtedly this species.

The black-head minnow is apparently the most abundant and most widely distributed fish in North Dakota. It has a marked preference for lakes and other bodies of quiet water; and it seems to occur in all such places of perennial nature with water not too strongly alkaline; and it appears to tolerate a higher degree of alkalinity than any other species except the stickleback (*Eucalia inconstans*). With this fish it is frequently associated; and often these two apparently made up the entire abundant fish population of a body of water. Such was found to be the case in Irwin, Sweetwater, Court, and Metagoshe lakes and in Mauvaise and English coulées and in a part of Willow Creek. In two lakes, Fish and Irvine, only black-head minnows were found. The distribution of this minnow with the stickleback in North Dakota seems to indicate that they can live in waters of high degrees of salinity, but complete data on the amount these fish can endure are lacking. In Devils Lake at present seemingly only sticklebacks occur, but formerly, as late as 1906 (Pope, 1908), both were abundant there. At that time the water of the lake had solids 8,517

parts per million. Later, after black-head minnows had disappeared, or nearly so, the lake water contained 15,889 p. p. m. (Abbott, 1925, p. 182); and according to Young (1924, p. 28) 15,210 p. p. m. The inability of this minnow to tolerate these high concentrations may account for its disappearance in Devils Lake. Its former abundance is noted by Pope (1908, p. 17), when, with sticklebacks, they were taken "by the hundreds." In Sweetwater Lake we found this minnow very abundant and thriving in 1922. This lake had a concentration of 694 in 1911 (Brannon, 1912, pp. 14–15). Breeding males of this species, characterized by nuptial tubercles on the head and dense pigmentation of the body, were collected in considerable numbers in June, 1926, by Hubbs and Schultz, principally from Apple Creek and a pond near Hettinger.

35. Campostoma anomalum (Rafinesque). Stone-roller Minnow. — James River, abundant (Woolman, 1896); James River at Mitchill, S. D. (Evermann and Cox, 1896).
36. Ictalurus punctatus Rafinesque. Channel Cat. — Red and Little Missouri rivers (Hankinson); Little Missouri River (Hubbs and Schultz); Red River (Woolman, 1896); Red River at Winnipeg (Eigenmann, 1894). Eigenmann here says that it is exceedingly abundant in the Red River, where it is caught especially at night, and frequently reaches a length of 750 mm.
37. Ameiurus melas melas (Rafinesque). Black Bullhead. — Red and James rivers and Spiritwood Lake (Hankinson); Arrow Wood and Jim lakes and Sheyenne River (R. T. Young); Maple, James, Curlew, Heart, and Little Missouri rivers and pond near Hettinger (Hubbs and Schultz); Sheyenne, Maple, and Goose rivers (Woolman, 1896). Apparently the most common bullhead of the region, and very generally distributed in streams and probably more common in lakes than our collections indicate.
38. Ameiurus nebulosus (Le Sueur). Common Bullhead. — Sheyenne River (Hankinson); Sheyenne River (Young); James River (Woolman, 1896). Evidently common in the

Sheyenne River and associated with the black bullhead there.

39. Ameiurus natalis (Le Sueur). Yellow Bullhead. — James River (Woolman, 1896).
40. Schilbeodes gyrinus (Mitchill). Tadpole Cat. — Red River; apparently common there (Hankinson); Red, Goose, Maple, and Sheyenne rivers (Woolman, 1896).
41. Noturus flavus Rafinesque. Yellow Stone-cat. — Little Missouri, Cannon Ball, and Heart rivers (Hubbs and Schultz).
42. Esox lucius Linnaeus. Northern Pickerel or Pike. — Red, Sheyenne rivers and Pipestone Creek; Wood and Red Willow lakes (Hankinson); Maple and Sheyenne rivers (Hubbs and Schultz); Sheyenne River (Pope, 1908, p. 18); Goose, Park, Sheyenne, James, Mouse rivers and Red Lake River in Minnesota (Woolman, 1896); James River at Mitchill, S. D. (Evermann and Cox, 1896); Devils Lake (Lord, 1884; Pope, 1908, pp. 3, 18; Young, 1917, pp. 501, 504; 1924, p. 98); near Turtle Mountains (Jordan, 1878).

    This is the principal game fish of North Dakota and occurs there in many waters. In Wood Lake it is sufficiently large and abundant to furnish sport. In August, 1922, we saw a string of about a dozen averaging perhaps eighteen inches in length that had been taken by two anglers. The abundance of shallow water here, with a maximum depth of about twenty-five feet, the extensive areas of aquatic plants, the many perch and other smaller fish suitable for food for the pike, and clear water of low salinity, help to make an environment favorable for the species. Good fishing could be maintained in Wood Lake indefinitely if the pike are properly cared for there by preventing overfishing and winter killing, which can be done by making air holes in the ice.

    The history of this species in Devils Lake is of interest since the species was very abundant there, but it disappeared suddenly and, apparently, completely about 1889 (Pope, 1908, p. 3). The fish were captured and sold by the car load; they averaged from five to six pounds in weight; and a number were taken that were from 17 to 18 pounds and

larger (Pope, 1908, pp. 18–19). The reason for this sudden disappearance has never been fully and satisfactorily explained, although a considerable amount of biological investigation has been undertaken to solve this problem and to make it possible to reëstablish the species as well as other useful fish in the lake (see Pope, 1908, and the several papers by Young, Abbott and others).

Woolman (1896) found the pickerel common in the Sheyenne and abundant in nearly every station he visited, and he notes many fine specimens taken from a mill pond at Jamestown with hook and line. He considers it "Preëminently the food and game fish of this section of the country."

43. FUNDULUS DIAPHANUS MENONA Jordan and Copeland. Menona Killifish. — Lake Williams, near Streeter, N. D. (R. T. Young); Sheyenne River (Woolman, 1896). The fish from Williams Lake are of especial interest. The lake is of the alkaline type. Dr. Hubbs in examining the specimens notes a resemblance to the typical subspecies of the coastwise water along the Atlantic Coast.

44. PERCOPSIS OMISCOMAYCUS (Walbaum). Trout-perch. — Red, Pembina, Park, and Sheyenne rivers (Hankinson); Sheyenne River (R. T. Young); Sheyenne River at Valley City (Hubbs and Schultz); Red, Pembina, Goose, Sheyenne rivers and Red Lake River in Minnesota (Woolman, 1896); Red River at Winnipeg (Eigenmann, 1894); Red and Souris rivers in Manitoba (Thompson, 1898). A common species in the Red River and tributaries; none was taken in the Missouri system in our collections.

45. PERCA FLAVESCENS Mitchill. Common Perch. — Wood, Red Willow, Belcourt, Dion lakes and James River, abundant in each (Hankinson); Arrow Wood, Red Willow, Juanita, and Spiritwood lakes (R. T. Young); James and Cannon Ball rivers (Hubbs and Schultz). The perch becomes abundant in certain non-alkaline waters of North Dakota. In the lakes it was found to reach a large size. Wherever these large fish were found, they were sluggish and easily dipped from open lake water with a six-foot seine. They did not seem to be

sought with enthusiasm by anglers. Many of the fish showed evidence of disease. It was reported that perch were at one time planted in Fish Lake and that fishing for them was excellent for years; some weighed as much as two pounds. In 1922, none was found in the lake, and residents of the region attribute their disappearance to thick winter ice, which covers the lake for long periods each year. Efforts to acclimatize perch to the alkaline waters of Devils Lake have been made with promise of success (Pope, 1908, p. 21). Such investigations are worthy of continuation. Woolman (1896) said that the perch was not frequently taken in streams, but it was reported to be in nearly all lakes of the state. Forbes and Richardson (1909) consider the Red River to be the northernmost extent of the range of the species. The perch undoubtedly is deserving of considerable attention by the fish interests of North Dakota.

46. Stizostedion vitreum Mitchill. Yellow Pike-perch. — Pembina and James rivers (Hankinson); James River in South Dakota (Evermann and Cox, 1896); Red River at Grand Forks (rare), Red River tributaries in Minnesota, and Sheyenne River at Valley City (Woolman, 1896); Winnipeg (Eigenmann, 1894).
47. Hadropterus maculatus (Girard). Black-sided Darter. — Red, Pembina, and Sheyenne rivers (Hankinson); Sheyenne River (Hubbs and Schultz); Red, Pembina, Forest, Park, Maple, James, Goose, and Mouse or Souris rivers (Woolman, 1896); Winnipeg (Eigenmann, 1894). Generally distributed in the streams of the Red River system, but apparently uncommon.
48. Imostoma shumardi (Girard). River Darter. — Red River at Pembina; one specimen only taken (Hankinson); Red River near Grand Forks, and Red Lake River in Minnesota, under the synonymic name *Etheostoma guntheri* Eigenmann and Eigenmann (Woolman, 1896); Winnipeg (Eigenmann, 1894).
49. Boleosoma nigrum nigrum (Rafinesque). Johnny Darter. — Pembina, Park, Sheyenne, and James rivers, Pipestone Creek (Hankinson); Sheyenne River at Valley City (Hubbs

and Schultz); Sheyenne, Maple, Buffalo, Goose, Mouse, and Red River tributaries in Minnesota (Woolman, 1896).

50. Poecilichthys exilis (Girard). Iowa Darter. — Red Willow, Gordon, Spiritwood lakes, and James River (Hankinson); Spirit Wood and Arrow Wood lakes (R. T. Young); pond near Hettinger (abundant), James River, and Sweet Briar Creek (Hubbs and Schultz); Cannon Ball River (Evermann and Cox, 1896); Sheyenne, Park, and James rivers (Woolman, 1896).

    This darter was found especially abundant in Gordon Lake in the Turtle Mountains on September 3, 1922. Breeding colors were evident, though subdued in some of the specimens. A breeding male in high coloration was taken June 9 by Hubbs and Schultz from the pond near Hettinger.

51. Aplites salmoides (Lacépède). Large-mouth Black Bass. — Red Willow Lake and Sheyenne River at Lisbon (Hankinson); Red Willow Lake (R. T. Young); Red River (Goode, 1903, p. 56). The specimens found were all small, young fish.

52. Helioperca incisor (Cuvier and Valenciennes). Blue-gill. — Wood, Belcourt, Gordon, Dion lakes, and Sheyenne River at Lisbon (Hankinson). Examples taken were nearly all young ones and from shallow water, since deep water collections were not made by us. They were abundant in all the places found. It is evident that blue-gills have been planted in North Dakota waters and probably are not native there, since Woolman did not record the species from North Dakota.

53. Allotis humilis (Girard). Orange-spotted Sunfish. — James River at Jamestown; two taken (Hubbs and Schultz); James River at Mitchill, S. D. (Evermann and Cox, 1896).

54. Eupomotis gibbosus (Linnaeus). Common Sunfish. — Belcourt Lake; few taken (Hankinson); pond in Hidden Wood Creek, at Hettinger, N. D.; common (Hubbs and Schultz).

55. Ambloplites rupestris (Rafinesque). Rock Bass. — Red and Pembina rivers (Hankinson); Maple, Sheyenne, and Red Lake River in Minnesota (Woolman, 1896). Woolman re-

fers to the rock bass as the only member of the Centrarchidae found in these waters.

56. Eucalia inconstans (Kirtland). Common Stickleback. — Irvine, Irwin, Sweetwater, Court, Devils, Carpenter, Jarvis, Gordon, and Metagoshe lakes, Mauvaise and English coulées, pond cut off from Stump Lake, Red River, and Willow Creek (Hankinson); Apple and Sweet Briar creeks, Curlew River, and pond in Hidden Wood Creek (Hubbs and Schultz); Court, Willow, Buffalo, Carpenter, Stump, Devils, Etta, Jarvis, Ensign, Gordon, and Strawberry lakes, Eastgate's and Wheeler's ponds (R. T. Young); Maple, Goose, Sheyenne, Forest, Red, and Mouse rivers, English Coulée at Grand Forks, and Red Lake River in Minnesota; widely distributed (Woolman, 1896); Devils Lake (Pope, 1908).

This is the most widely distributed fish in North Dakota, according to known records. It was abundant only where there was much plant life, and the patches of ditch grass (Ruppia) formed favorite homes for it. In this growth, sticklebacks breed in Devils Lake, according to Young (1924, p. 102). We found it living under higher degrees of alkalinity than any other fish, but with the increasing concentration of salts in Devils Lake the species is evidently disappearing, for we found but few there in 1922, while they were formerly exceedingly abundant and formed a plenteous supply of food for gulls, cormorants and, undoubtedly, other water birds (Pope, 1908, pp. 7, 17). In 1922 sticklebacks were living in Devils Lake in water with solids near 15,000 parts per million, since Young (1924, p. 28) reports 15,210 p.p.m. The association of sticklebacks in North Dakota lake waters with *Pimephales promelas* is of ecological interest and is discussed in the description of this last-named species.

57. Lota maculosa (Le Sueur). Burbot. — Red River at Grand Forks (Hankinson); Painted Woods Lake near Washburn, N. D. (R. T. Young); Red River at Moorhead and elsewhere, Red Lake River in Minnesota (Woolman, 1896). Woolman reports it occasionally taken on a "trot line" from the Red River, but not common.

It is evident that further field-studies and more collections from North Dakota would reveal species not recorded in the foregoing list. From occurrences in regions adjacent to North Dakota and elsewhere in the stream systems not wholly in the state, it appears that the following listed species of fish may occur in North Dakota:

1. Acipenser fulvescens Rafinesque. Lake Sturgeon. — Red River System of Minnesota (Surber, 1920).
2. Lepisosteus osseus (Linnaeus). Long-nose Gar. — Otter Tail Creek, a tributary of the Red River in Minnesota (Woolman, 1896).
3. Salmo irideus Gibbons. Rainbow Trout. — Reported by residents as formerly common in some lakes of the Turtle Mountains. Some reported taken in 1922.
4. Carpiodes cyprinus (Le Sueur). Quillback Sucker. — Red River system of Minnesota as *C. thompsoni* Agassiz (Surber, 1920); Red River at Winnipeg as *C. velifer* (Evermann and Goldsborough, 1907).
5. Moxostoma aureolum (Le Sueur). Common Red-horse. — Red River at Winnipeg (Eigenmann, 1894).
6. Moxostoma anisurum Rafinesque. White-nose Red-horse. — Red River at Winnipeg (Eigenmann, 1894).
7. Catostomus catostomus (Forster). Northern Sucker. — Red River, Winnipeg (Eigenmann, 1894); Souris River near mouth (Thompson, 1898).
8. Couesius plumbeus (Agassiz). Lake Chub. — Upper Missouri River (Jordan and Evermann, 1896).
9. Notropis topeka Gilbert. — James River, Mitchill, S. D. (Evermann and Cox, 1896).
10. Notropis hudsonius selene (Jordan). — Red River at Winnipeg (Eigenmann, 1894). Given here as *N. scopifer* Eigenmann and Eigenmann.
11. Notropis lutrensis (Baird and Girard). Redfin. — James River, Mitchill, S. D. (Evermann and Cox, 1896).
12. Fundulus sciadicus Cope. — South Dakota (Jordan and Evermann, 1896).

13. Stizostedion canadense griseum (De Kay). Sauger. — Red River, Winnipeg (Eigenmann, 1894).
14. Micropterus dolomieu Lacépède. Small-mouthed Black Bass. — Reported as formerly abundant in Belcourt Lake in the Turtle Mountains, and fishing for them was excellent with large examples frequently taken, but reported absent from the lake now, owing to winter killing in years just prior to 1922.
15. Xenotis megalotis (Rafinesque). Long-eared Sunfish. — Big Stone Lake, near the Red River system in Minnesota (Woolman, 1896).
16. Pomoxis annularis Rafinesque. White Crappie. — Big Stone Lake, Minnesota (Woolman, 1896).
17. Aplodinotus grunniens Rafinesque. Sheepshead. — Red Lake River, Minnesota (Woolman, 1896); Red River, Winnipeg (Eigenmann, 1894).

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DIVERSE TYPES OF YOUNG IN A SINGLE SPECIES OF FISH, THE GIZZARD SHAD

CARL L. HUBBS AND STANLEY C. WHITLOCK

I

IN THE course of a systematic study of the fishes of Oklahoma, the senior writer discovered some very peculiar young of the gizzard shad, *Dorosoma cepedianum* (Le Sueur). These had been caught about July 1, 1927, in a very muddy backwater of the Arkansas River, five and one-half miles southwest of Fort Smith. They varied in total length, excluding the caudal fin, from 22.4 to 75 mm.

The several hundred specimens representing the lower half of this range in size, with three clear-cut exceptions, are uniformly all of such unusual appearance that at first it was questioned whether they might not represent a distinct species (see Fig. 31). Their heads are so long and wide and swollen, and their eyes so large, however, that they look more like terata than normal young clupeids. This teratological facies is greatly enhanced by the state of development of the urosome, which, in striking contrast to the enlarged anterior parts, appears positively stunted. This underdevelopment of the tail region is shown both by the lesser length behind the anus and by the lesser depth of the caudal peduncle.

In striking contrast to these macrocephalic individuals from the Arkansas River are a series of young of like sizes from an overflow pond of the Poteau River, collected at the same time five miles southwest of south of Fort Smith, thus only a few miles distant from the locality whence the abnormal ones were secured. The Poteau specimens, with one obvious exception, appear wafer-like in contrast with those from the Arkansas, and have shorter and narrower heads, smaller eyes, and longer and deeper tails. These differences are indicated by Figure 31.

The exceptional specimens in the Arkansas River series, and the one abnormal one from the Poteau, were probably in each case recent migrants from the other stream.

The larger of these Arkansas River young show a decreasing

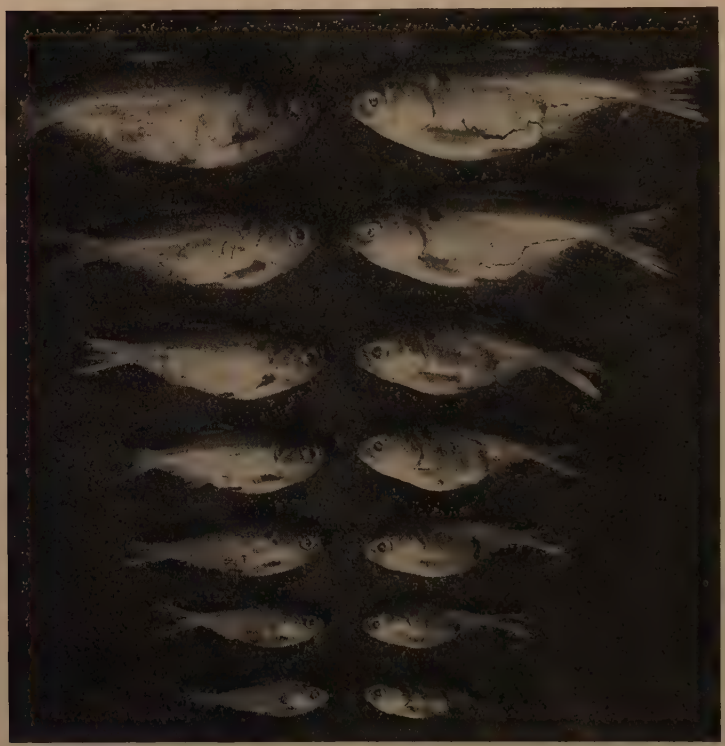

FIG. 31. Normal (left) and abnormal (right) young of gizzard shad, *Dorosoma cepedianum* $\times \frac{3}{5}$

The normal specimens are from the Poteau River, the abnormal ones from the Arkansas. In the latter note the swollen heads, large eyes, and stunted tails of the very young. Note also the decreased differentiation in the larger fishes.

degree of abnormal appearance, roughly in proportion to their size. When a series of graded lengths is laid out, side by side with one made up of normal-appearing young of similar sizes (as in the figure), it is evident at a glance that both types merge into large young which present a fairly uniform appearance.

It is even questionable whether the largest specimens of the two series could be distinguished; any differences in appearance would apparently be of average significance only.

As further evidence of the view that these two types of young shad are conspecific, we may state that we could find no differences in the number of countable parts. In a specimen about 65 mm. long of each series slightly more than 300 gill-rakers were counted on the first arch. In each series the anal rays were found to vary from 30 to 36. In each, the vertebrae average 50.0:

	Vertebrae counts in Dorosoma		
	49	*50*	*51*
Arkansas River	2	9	2
Poteau River	1	11	1

Furthermore, young from certain other localities were found to be variously intermediate between those in the Arkansas and Poteau samples (Fig. 38).

It would hardly be expected that the gizzard shad would show any sharp racial differentiation, since the adults are free-roaming fishes of the rivers. Certainly no racial differences would be expected between populations from the Arkansas River near the mouth of the Poteau, and from the lower end of the Poteau.

We think, therefore, that such differences as we have found are traceable to direct environmental action. These young must be subjected to sharp differences in temperature, chemical composition of water, food, etc., since they tend to pass their infancy in cut-off ponds.

II

In seeking for an explanation of the wide differences shown by the young from the Arkansas and Poteau rivers, we were naturally led to examine the specimens for parasites, since early parasitization has been indicated as the cause of somewhat similar modifications in another fish (Hubbs, 1927). A careful examination of several specimens of different sizes in each series, however, failed to disclose any parasites.

The contents of the alimentary canals served to strengthen an early suspicion that the abnormal development in the Arkansas might be related to the thick siltiness of the water during the

great floods of 1927. The guts of the Arkansas River individuals were jammed tight with fine inorganic material — clay, mica, silica, etc. — obviously ingested in the open water feeding characteristic of the species; even the numerous pyloric caeca were often turgid with the same material, looking like the fingers of a glove filled with water. Apparently not more than one particle in a hundred swallowed was a desmid or a diatom. The alimentary canals of the Poteau specimens, in contrast, were moderately filled with little else than entomostracan remains.

It is possible that this tremendous excess of inorganic roughage in the food may have led to differential inhibition along the double-headed axial gradient of the growing young fish (Child, 1920, 1924, 1925; Hyman, 1921), and have thus disturbed the normal size relations of anterior and posterior parts.

III

In order to analyze the differences between the young of *Dorosoma cepedianum* from separate regions we made a long series of measurements. These are listed and summarized on the accompanying graphs. The six measurements taken in every case were made by means of an accurate pair of dividers, and read on a steel rule to tenths of a millimeter. All the specimens had been well preserved, first in formaldehyde and later in alcohol. The total length was taken from tip of snout to the structural base of the caudal rays, after the specimen, if somewhat distorted on preservation, was straightened out into natural position. The length of the head was similarly measured, and to the end of the opercular membrane. The width of the head was taken at the widest point, not considering the opercles if expanded. The length of the eye was measured across the silvery cornea. The length of the tail was calculated as the distance between the origin of the anal fin and the base of the middle caudal rays. The least depth of the caudal peduncle was used.

All the specimens from the Poteau were measured, as were also all the larger ones from the Arkansas, as well as a sufficient number of the smaller ones.

The measurements of the five parts of the body used for both

series of specimens have been plotted as ordinates against the total length. The resulting graphs are reproduced as Figures 32 to 36 of the present paper. The curves on these five figures are designed to average the observations, so as to show the trend of the growth of each of the five parts of the fish in each of the two series. The curves were drawn free-hand, and an effort then made to reproduce them by an analytical equation.[1] After many failures, an equation was found which would very faithfully reproduce the six curves drawn up from the measurements of the anterior parts of the fish — namely, length of head, width of head, and length of eye. This equation is

$$(1)\quad y = a + b \log x + c \log^2 x,$$

in which y is the dimension of the part; x the total length, and a, b, and c are constants. The two curves for the length of the tail, the growth of which appears to bear a more or less complementary relation to that of the anterior parts, were equally well reproduced by the equation

$$(2)\quad x = a + b \log y + c \log^2 y, \qquad \text{whence}$$

$$(3)\quad y = \text{antilog} \frac{-b \pm \sqrt{b^2 - 4c(a-x)}}{2c}.$$

The two curves for the depth of the caudal peduncle are clearly sigmoid, but time has not permitted an attempt to reproduce them by an equation. These two curves must in fact be doubly sigmoid, since another flattening would be required to bring the values toward the 0–0 point.

The computed values of the dimensions of the parts, as determined by the equations cited, seldom varied more than the width of the line from the values indicated by the initial free-hand curves. In the few cases of discrepancies, the computed values seemed to fit the measurements the better. For subsequent analyses, therefore, we employed the computed values of y (the dimension of the part) for each 4 mm. interval of x (the body length), between 24 and 80 mm. In the case of the depth

[1] For mathematical advice we are indebted to Professor Theodore R. Running of the University of Michigan, and for much assistance in the computations we are grateful to Mrs. Laura C. Hubbs.

of the caudal peduncle, the values were read directly from the graph. Certain irregularities in the observations, especially at lengths of 50 to 60 mm., are not reproduced by the equation used, although these are probably of significance.

Whether any specific significance is inherent in these equations remains to be determined, as does also the possibility of their general application to the relationship of the growth of one part of the organism to that of the whole. This relation, at least for the early period of growth, seems to be a logarithmic one, but not of the simplest order.

It is clear that in none of the ten curves shown in Figures 32

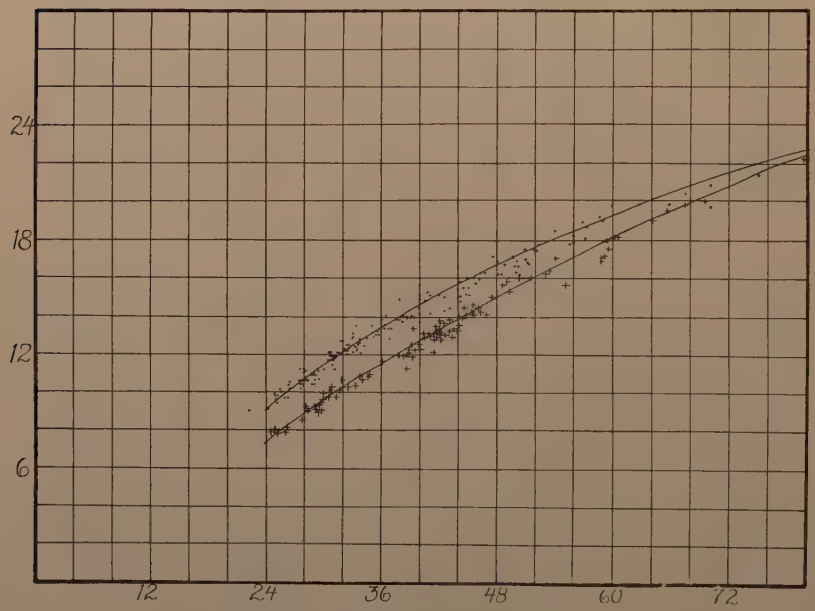

FIG. 32. Length of head in abnormal and normal young of *Dorosoma cepedianum*

The ordinates represent the measurements of the length of the head in millimeters; the abscissae, the total lengths in millimeters. The records for the abnormal or Arkansas specimens are plotted as dots; those for the normal or Poteau specimens, as crosses. Note the downward trend of the curves, and their convergence. Curve drawn through points determined by formula (1), with these values for the constants: $a = -16.88$, $b = 13.47$, $c = 3.87$ for the abnormal young, and $a = 10.0$, $b = -24.2$, $c = 16.17$ for the normal ones.

to 36 would a straight line adequately express the growth relation. This agrees with our findings for the growth in length of head and depth of body in the two subspecies of California anchovy (Hubbs, 1925), and is opposed to the generalization of Crozier and Hecht (1914) and Hecht (1916) that the dimensions of the parts of the body of a fish are linear functions of the total length. Although young, the fishes we measured were all far beyond the embryonic and postlarval cycles of growth, so that the curvatures in the lines of growth of the parts cannot well be attributed to such a disturbing influence. Nevertheless we notice that the upper halves of our curves approach a straight line. Measurements of still larger young of *Dorosoma*, as those from the Verdigris River in Oklahoma (Fig. 40), when plotted against total length yield a

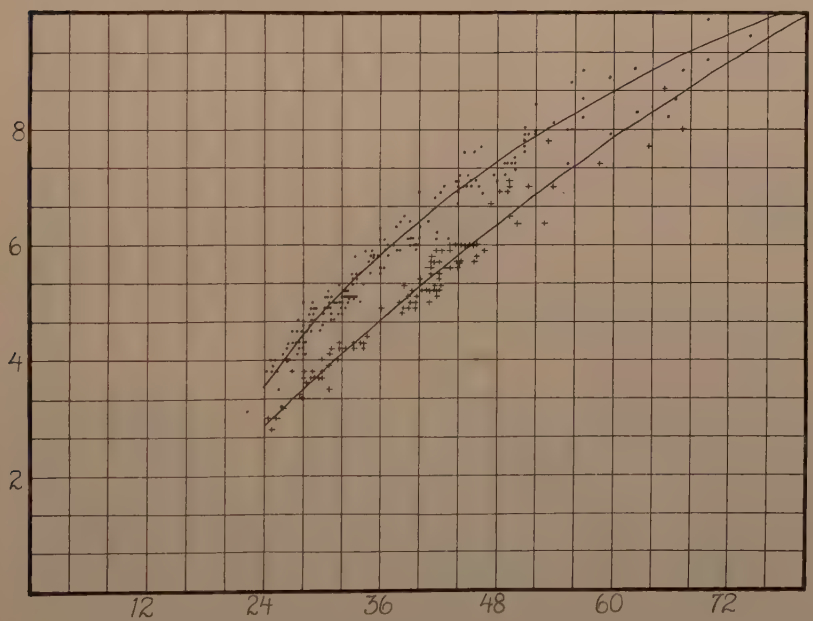

FIG. 33. Width of head in abnormal and normal young of *Dorosoma cepedianum*

For explanation see Figure 32. Curve drawn through points determined by formula (1), with the following values for the constants: $a = -14.57$, $b = 13.49$, $c = -0.24$ for the abnormal young, and $a = 7.62$, $b = -15.83$, $c = 8.97$ for the normal ones.

curve which still more closely approximates a straight line. We suspect that the marked changes in the increments of the growth of the different parts of the body, which seem to be characteristic of very young fishes, are carried with decreasing intensity well into and perhaps entirely through the whole life-cycle. We had already come to this conclusion in discussing the remarkable growth changes of the ribbon fish, *Trachypterus* (Hubbs, 1926 b). It is of course true, despite this reservation, that the dimensions of the parts of a fish throughout the greater portion of its life-history do bear a relation closely approaching that of the linear to the total length.

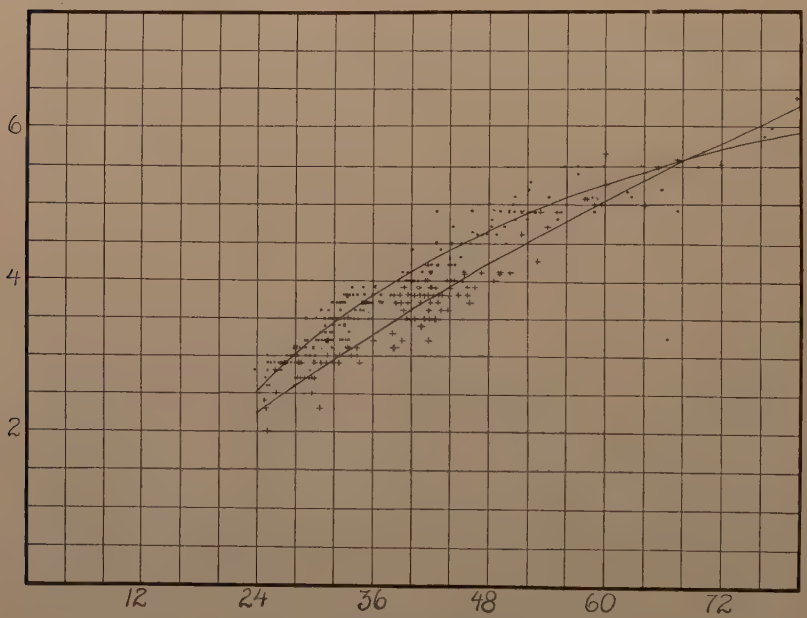

FIG. 34. Length of eye in abnormal and normal young of *Dorosoma cepedianum*

For explanation see Figure 32. The values for the constants for the abnormal specimens are: $a = -13.39$, $b = 15.07$, $c = -2.58$; for the normal ones, $a = 5.18$, $b = -9.23$, $c = 5.15$.

IV

Each of the graphs given as Figures 32 to 36 shows the differences between the Arkansas and Poteau specimens in a single character. This expression of difference is inadequate in several respects. In the first place, it fails to show to which type given specimens belong when these are on the area of overlap of measurements for the particular character under observation; thus, one of the Arkansas specimens might have the tail as long as in the Poteau series, but be quite dissimilar in all the other respects. In the second place, the differences in appearance between the two types are inadequately expressed by the measurements of any

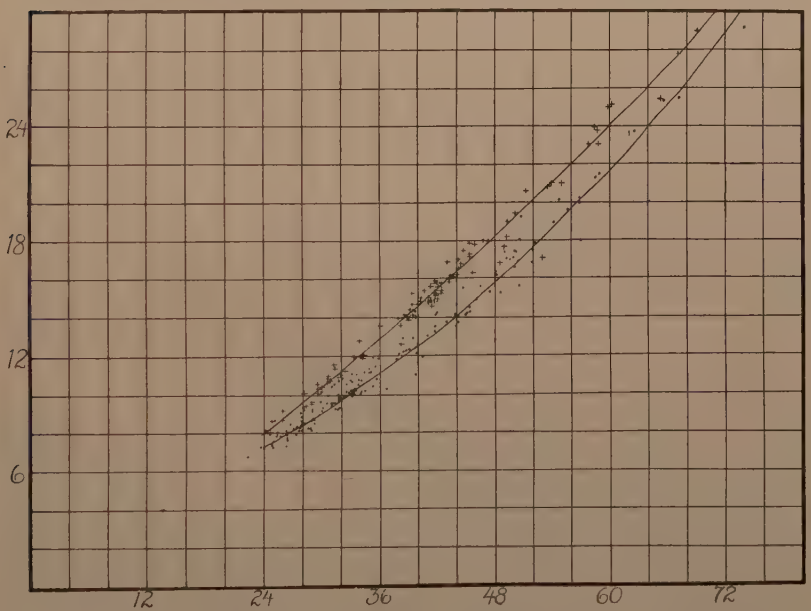

FIG. 35. Length of tail (origin of anal fin to base of caudal) in *Dorosoma cepedianum*

The dots, as before, represent the measurements of the abnormal specimens; the crosses, those of the normal or Poteau specimens. The lengths of tail are plotted as ordinates against the total length; both are given in millimeters. Note that these curves bend upward instead of downward. They were drawn through points determined by formula (3), with the following values for constants: $a = 38.51$, $b = -75.84$, $c = 66.18$ for the abnormal specimens, and $a = 0$, $b = -2.22$, $c = 35.24$ for the normal ones.

single character, because in visually comparing two types we size up the differences in a composite fashion.

The same situation arises in racial investigations, and to meet this difficulty we have devised a means of expressing all the measured differential characters of an individual in a single figure, which we term the *character index*. This coefficient is obtained by a simple arithmetic combination of the measurements for each individual. It is designed not only to combine all the measurements into a single expression, but also to emphasize any total difference which does exist. In the present case the character index is obtained by dividing the product of the proportionate length of tail and the proportionate depth of caudal peduncle into the product of the proportionate length of head, the proportion-

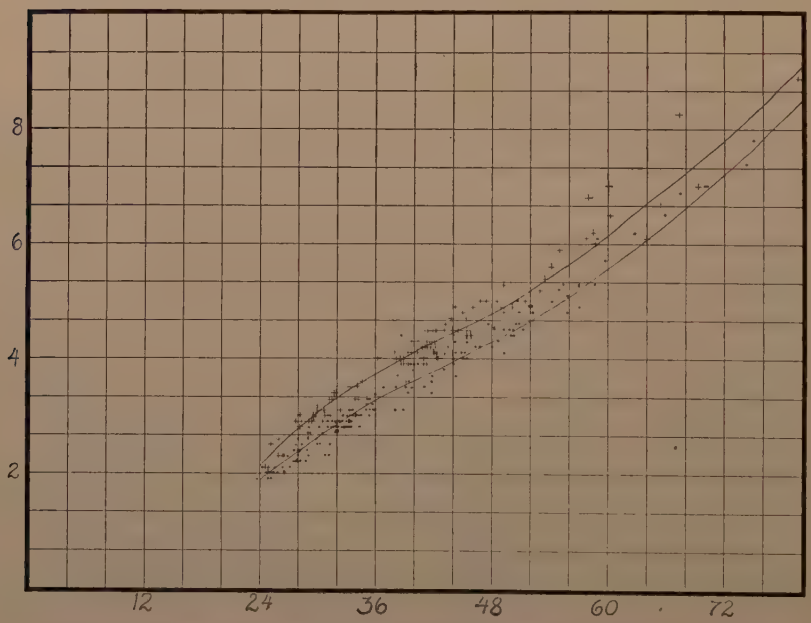

FIG. 36. Depth of caudal peduncle in abnormal and normal young of *Dorosoma cepedianum*

The measurements are in millimeters; the least depths of caudal peduncle are plotted against the total length. The clearly sigmoid curves are drawn free-hand.

ate width of head and the proportionate length of eye. Since in the Arkansas series the tail averages both short and slender, the product of the length and depth proportions emphasizes the underdevelopment of the tail region, as compared with the Poteau young, in which both dimensions of the tail are larger. Since the anterior parts as a whole are developed to excess in the Arkansas type, this fact is brought out intensely by multiplying together the proportionate length of head, width of head and length of eye. Further, since the anterior parts are developed better in the Arkansas type than in the Poteau, whereas the reverse is true of the posterior parts, the differences between the two types are emphasized by dividing the products of the proportionate sizes of the anterior parts by the products of the proportionate sizes of the posterior parts. If we express the length of the head as y_1, width of head as y_3, length of eye as y_5, length of tail as y_7, and depth of caudal peduncle as y_9, and the total length as x, then the formula for the present character index is

$$(4)\quad \text{character index} = 1000\,\frac{\frac{y_1}{x}\,\frac{y_3}{x}\,\frac{y_5}{x}}{\frac{y_7}{x}\,\frac{y_9}{x}},$$

which simplified for ready computation becomes

$$(5)\quad \text{character index} = \frac{1000\,y_1\,y_3\,y_5}{x\,y_7\,y_9}.$$

The factor 1000 is introduced merely to avoid decimals. It is obvious that, since the measurements for all individuals are accorded the same arithmetic treatment, no differences which are not real are brought out by the use of the character index. Just as the differences between types or races are emphasized by the use of the index, so also is any variability exaggerated.

The character indices for all the individuals of the Poteau and Arkansas series are plotted on Figure 37. The great difference between the smaller specimens of the two lots is very clearly brought out. In the character index the differences between the two types reach more than 100 per cent, whereas in no individual item does the difference rise to 30 per cent (Fig. 38 A).

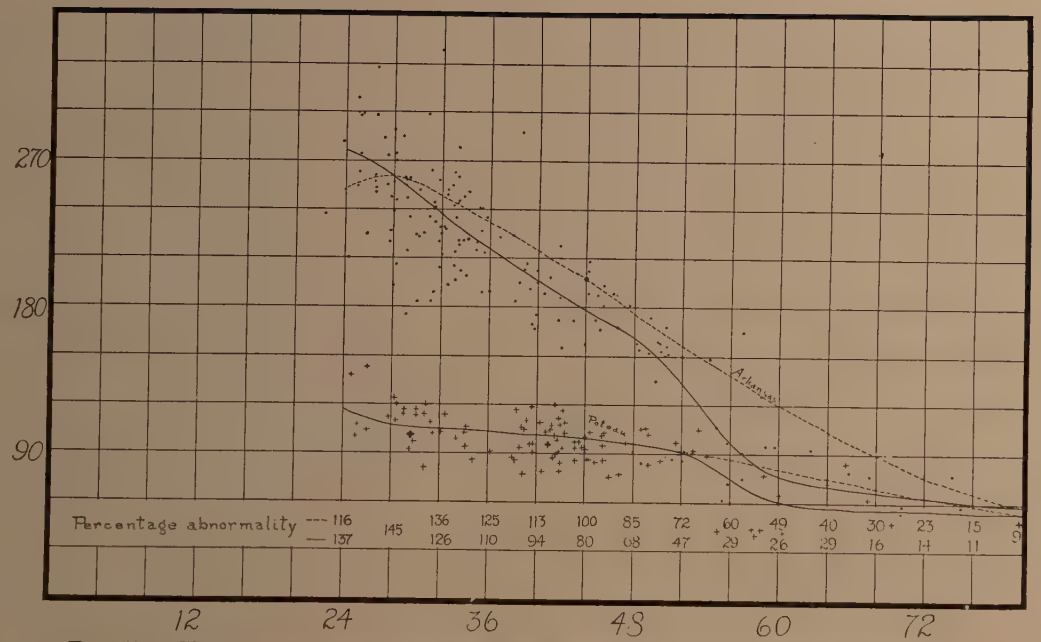

FIG. 37. Character indices for abnormal and normal young of *Dorosoma cepedianum*

The dots represent the individual indices for the abnormal specimens (the Arkansas River sample); the crosses, the indices for the normal ones (Poteau sample). The indices are plotted, as ordinates, against the total length. They were determined by formula (5). The solid lines are drawn free-hand; the broken ones pass through points determined by applying the formula to the average values of each character at each 4-mm. interval, in turn determined as indicated on Figures 32–36.

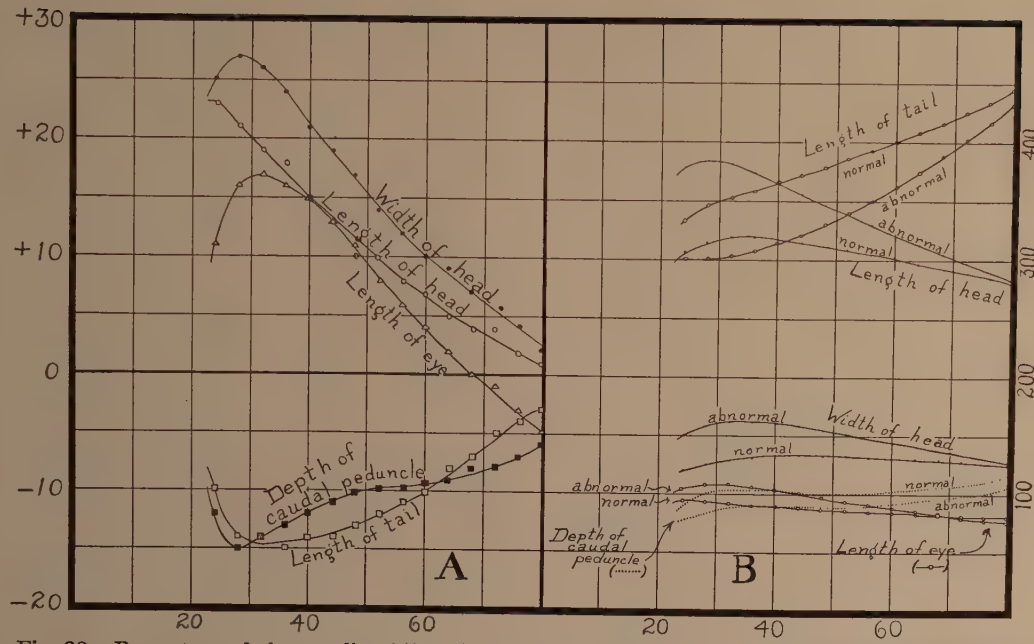

Fig. 38. Percentage of abnormality (*A*) and proportionate size of parts (*B*) in *Dorosoma cepedianum*

The percentage of abnormality, obtained by formula (8) as indicated in the text, shows the deviation of the abnormal Arkansas River specimens from the normal ones from the Poteau, and their return to normalcy with advanced size (total lengths plotted as abscissae). The proportionate size of the parts, determined by formula (6) as indicated in the text, is plotted against total length in Figure *B;* the marked changes in the proportions with age are thus clearly shown.

The character index, representing as it does a composite of the differential features, is very serviceable in comparing age changes in two lots, and in comparing isolated individuals with two or more types. This index is so employed in the following sections of the paper.

V

The plotting of the character index against total length (Fig. 37) gives a graphical idea of the decreasing difference, with size, of the young gizzard shad from the Arkansas and Poteau rivers. Although at first so widely different, the character indices for the two lots so rapidly approach, that at a length of 80 mm. only a slight average difference, if any, persists. Since the character index normally decreases a little with advanced size, the sharp downward slope of the character index curve for the abnormal specimens represents an exaggeration of the normal growth tendency. In Figure 37 the percentage difference in average character index for each 4-millimeter interval in total length is listed on the graph. The broken lines indicating the average character index are drawn through points obtained by applying formula (5) to the average values of each character, at the given length, in turn determined as already indicated. The fact that the individual indices group fairly well about these lines shows that no very large errors have been made in determining the course of the curves in Figures 32 to 36. Some error was made, however, for the average curve for the abnormal specimens runs somewhat too high throughout (except at the end of the curve). Furthermore, an apparently sharp decline in both curves between 50 and 60 mm. is not brought out, because in Figures 32 to 36 the curves were not diverted from their main trends to follow the aberrant observations at this size. Character index curves which more closely agree with the observations are shown by solid lines on Figure 37.

The changes with increasing length in the proportionate sizes of each character for each of the two series are indicated on Figure 38 B. The proportionate size is obtained by the formula

$$(6)\quad \text{proportionate size} = \frac{1000\,y}{x},$$

in which y is the measurement of the part, and x is the total length. The values of y used are the average ones obtained as already explained. The proportionate sizes of the anterior parts (length and width of head and length of eye) first show an increase, which extends for a short distance, then a decrease of nearly constant rate, indicated by the long nearly straight portion of the curve. The rate of decrease in the proportionate sizes of these anterior parts is more rapid in the abnormal or Arkansas than in the normal or Poteau series. The curves, therefore, approach at their upper ends.

The proportionate length of the tail in contrast increases rapidly at first in the normal series, then more slowly, and very slowly at first in the abnormal set, but at an increasingly faster rate with age. As a result the curves approach at the upper end. The proportionate depth of the caudal peduncle increases at first in each case, then remains nearly constant, and finally again increases. The two sigmoid curves representing these facts seem to converge somewhat at their upper ends.

The degree of convergence of the proportionate sizes of the individual parts may be determined from the average values of the dimensions of the parts, and may be expressed as the percentage deviation of the Arkansas series from the Poteau lot. This expression of the percentage of abnormality of the macrocephalic young from the Arkansas is obtained thus:

$$(7)\quad \text{percentage of abnormality} = 100\,\frac{\frac{y_1}{x} - \frac{y_2}{x}}{\frac{y_2}{x}},\ \text{whence}$$

$$(8)\quad \text{percentage of abnormality} = \frac{100\,(y_1 - y_2)}{y_2}.$$

The curves indicating percentages of abnormality for each character at lengths between 24 and 80 mm. are portrayed in figure 38 A. The anterior parts show a positive deviation from the normal, at first increasing, then soon decreasing at a rate which is nearly constant. The posterior parts show a negative deviation from the normal, also increasing at first, then soon decreasing. As might be expected, the curve for the depth of caudal peduncle is more

complex than the others. At 80 mm. the percentage of abnormality for all the characters has decreased from a high point of 15 to 27 per cent to less than 7 per cent.

The recovery from abnormality thus indicated seems to be an example of compensatory regulation in the growth of the parts of the organism. Such regulation has been shown to apply to the growth of the tail in rats (Sumner, 1915). A similar principle of growth compensation appears to hold for the growth of the entire fish (Gilbert, 1914, pp. 61–71; Hubbs, 1921 a, p. 206, and 1921 b, p. 275). Growth compensation appears to us as only a phase of developmental regulation.

Two alternative explanations might be put forward to account for the lesser abnormality of the larger young in the Arkansas series. This might be due to their having been less subjected to the environmental conditions inducing the abnormality. Or the small size of the very abnormal specimens might be interpreted as due to their slower growth after their modification at a still earlier age. We do not know how to eliminate the possibility that either of these alternative hypotheses may apply to the present case, although they seem far less plausible than the theory we have advanced. Whatever the explanation may be, the occurrence of diverse types of young in *Dorosoma cepedianum* cannot be questioned.

VI

The young gizzard shad of the Arkansas and Poteau series appear to represent rather extreme types of differentiation. From some other localities, as the Minnesota River, we have young very much like those from the Poteau, but from other localities we have variously intermediate types. This agreement, or intermediacy, is well expressed by the character index, and is shown graphically on Figure 39. The lot from Verdigris River in northeastern Oklahoma, like the Poteau a tributary of the Arkansas, is made up of individuals varying between 50 and 100 mm. in length; of these the smaller are intermediate, whereas the larger maintain a higher character index than those from the Arkansas. They have been modified less, but have shown less recovery. This phenomenon

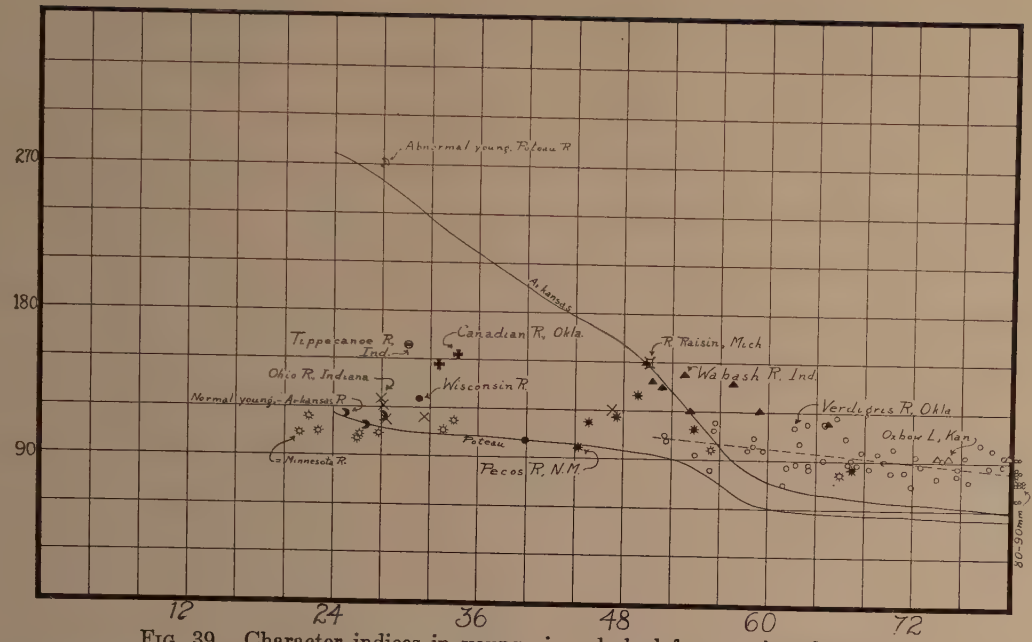

FIG. 39. Character indices in young gizzard shad from various localities

The indices are plotted as explained in the caption of Figure 37. The specimens from each locality are plotted with a characteristic symbol, for which the key is given on the graph. The average curves for the abnormal Arkansas specimens and normal Poteau ones are copied from Figure 37. The broken line is the curve for the Verdigris River sample. The indices for larger specimens of this series follow the same curve; for specimens 80–90 mm. long the values are given just to the right of the boundary line of the graph; for larger ones they are 61 at 95.4 mm., 60 at 99.1 mm. and 51 at 164 mm.

may be related to the apparently faster growth rate of the Verdigris specimens, which average much larger than those of the other lots, although taken only a few days later, in the same season.

The type of development as exhibited by the Verdigris River sample has been further analyzed and compared with that of the Arkansas and Poteau series. The comparisons are presented in graphical form (Fig. 40). On this graph the actual measurements of the Verdigris specimens are plotted, together with the growth curves for the same parts of the body in the Arkansas and Poteau series. The length and width of the head at first (50 to 55 mm.) are intermediate between those of the other two series, but soon become increasingly higher. The eye is generally small. The length of the tail is at first intermediate, but soon becomes increasingly lower than in the other sets. The depth of the caudal peduncle is at first greater even than in the normal or Poteau young, then becomes no higher, then intermediate between that of the Poteau and Arkansas sets, finally at least as low as in the Arkansas lot. Clearly the form development of *Dorosoma* in the Verdigris River sample is in sharp contrast to that exhibited by the Arkansas and Poteau series.

VII

This discovery of the existence of such diverse types of form development in the young of the gizzard shad forces us to proclaim a word of caution in using the proportions of the body in the young as racial or specific characters. A case in point comes at once to mind. Weed (1925) has lately proposed two new "subspecies" in the genus *Signalosa*, which is very closely related to *Dorosoma*, distinguishing one form solely and the other in part on the basis of a difference in the proportionate size of the head. Yet his specimens were all young ones, and the differences are no greater than those apparently produced by the direct environmental effect in *Dorosoma*. With this new information, we are led to question the validity of one or both of these new subspecies in *Signalosa*.

We are of course not suggesting that differences in proportions in the young are not usable as racial or specific characters, even

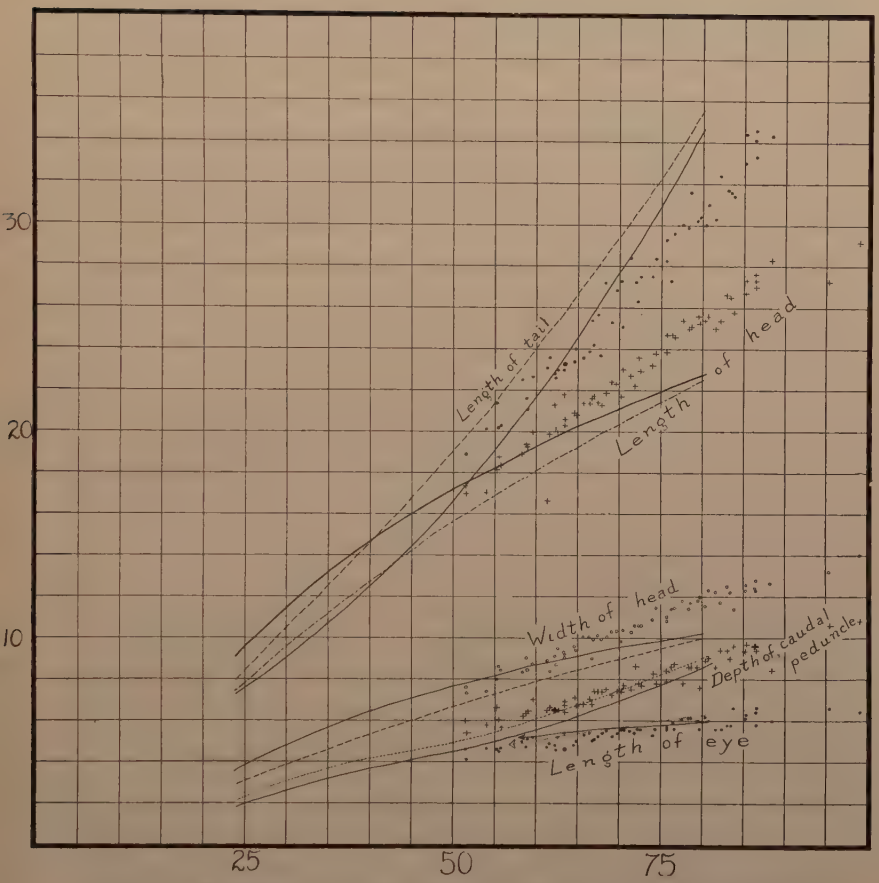

FIG. 40. Comparison of three diverse types of young gizzard shad

The measurements of the specified parts of the body are plotted as ordinates against the length — both expressed in millimeters. The actual records, dots, crosses and circles, relate to specimens from the Verdigris River. The two corresponding curves for each character are redrawn, on this new scale, from Figures 32–36. In every set of measurements the solid line is the curve for the Arkansas River series; the broken line, that for the Poteau set. The data are discussed in section VI of the text.

if such differences do not persist in the adult. We merely urge that such differences be regarded and used with caution.

VIII

In summary it may be said that we have found diverse types of form development in a single species of fish, the gizzard shad, *Dorosoma cepedianum*. Two extremes are represented by large series of specimens taken not far from one another, in the Arkansas and Poteau rivers in Oklahoma. The smaller Arkansas young appear teratological, on account of their long, wide, swollen heads, big eyes, and stunted tails; the Poteau young show contrasting characters.

The abnormality of the Arkansas River specimens does not appear to be due to parasitization, but may be related to the excessive siltiness of the water in which they were living.

The dimensions of the parts of the body as plotted against the total length do not form straight lines, although the curves approach a straight line at the larger sizes. The curves for the measurements of the anterior parts first rise, then soon fall; those for the posterior parts rise, those for the length of the tail at an increasing rate, those for the depth of the caudal peduncle in a sigmoid line. The curvatures are the greater for the abnormal or Arkansas series, and the percentage of abnormality in the proportionate size of the parts, though increasing at first, soon decreases at a nearly constant rate. As a result, the Arkansas and Poteau young differ only by a slight average amount at 80 mm.

The differences between these two types, their approach with age and the intermediate nature of specimens from certain other localities are all well shown and emphasized by the character index — a single figure representing the composite differential features of each individual — derived in the present case by multiplying together the characters which in one type are comparatively large and those which in the same type are comparatively small, and then dividing the former product by the latter.

The return to normalcy of the abnormal young in the Arkansas involves a compensatory regulation of the growth of the parts of the fish. This is related to compensation in the growth of the

whole fish, and may be interpreted as a phase of developmental regulation.

The existence of several types of young in *Dorosoma* indicates the need for caution in using the proportionate sizes of the parts of young fishes in racial or systematic investigations.

University of Michigan

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STUDIES ON THE TREMATODE FAMILY STRIGEIDAE (HOLOSTOMIDAE) No. XV: *DIPLOSTOMULUM GIGAS*, SP. NOV.*

R. CHESTER HUGHES AND PETER G. BERKHOUT

DURING the summers of 1926 and 1927 an apparently new species of Diplostomulum was found parasitic in the crystalline lenses of *Catostomus commersonnii* Lacépède at Douglas Lake, Cheboygan Co., Michigan. This species differs only in minor details from *Diplostomulum spathaceum* (Rudolphi) and may be identical with it. Considering, however, that in general the strigeids found in America belong to different species than those of Europe, it seems advisable to recognize the present form as a distinct species. Since the present form is considerably larger than another undescribed species[1] found in the eyes of certain other American fishes, we suggest the name **Diplostomulum gigas** for it.

The occurrence of diplostomula in the eyes of American fishes has been reported by Cooper (1915, p. 191), Ward (1918, p. 411), Butler (1919, p. 116) and La Rue, Butler, and Berkhout (1926, p. 284). Cooper classified his specimens as *Diplostomum volvens* von Nordmann, synonym of *Diplostomulum spathaceum* (Rudolphi).

In all the fishes examined the parasites occurred exclusively within the lens capsule, usually in the outer substance of the lens itself, and almost always massed together in the postero-mesial portion of the lens. Eyes in which the lenses contained fewer than 50 diplostomula generally appeared normal on superficial examination. In cases of heavy infestations, however, the pupils of the

* Contribution from the Biological Station and from the Department of Zoölogy, University of Michigan. This is the fifteenth of a series of studies on the family Strigeidae by Professor George R. La Rue, his students and associates.

[1] A description of this species is being prepared for publication by R. Chester Hughes and Lucilla Jane Hall.

eyes appeared opaque and the vision of the hosts was undoubtedly much impaired. The fact that the digestive organs of the diplostomula examined were invariably filled with a highly refractive granular substance indicates that the organisms ingest quantities of the lens material. The heavily infected lenses were often flaccid and misshapen. A careful study of the pathogenic effects of *Diplostomulum spathaceum* on the eyes of trout has been made by Salzer (1907).

MATERIAL AND METHODS

During the summer of 1926, 27 common suckers, *Catostomus commersonnii* Lacépède, from Douglas Lake were all found to be parasitized in both eyes with the present species. Records of the exact numbers of worms in each fish were not kept, but the most heavily infected host contained 280 diplostomula in one lens and 255 in the other. Four common suckers taken from Lake Superior (locality unknown) in March, 1927, had from 28 to 86 (average 58) diplostomula in each lens. Eleven common suckers, from 190 mm. to 372 mm. (average 307 mm.) in length, taken from Douglas Lake during the summer of 1927, contained from 12 to 152 (average 52) worms in each eye.

The method of study employed for the present species is in all respects similar to that used in the study of *Diplostomulum browni* by Hughes (1929). For purposes of comparison we have made use of several specimens of *Diplostomulum spathaceum* (Rudolphi) from the lenses of *Cobitis barbatula* collected at Breslau, Germany, and presented to Professor La Rue by Professor L. Scheuring of München.

Specimens of *D. gigas* used in this study are catalogued in the parasite collection of the Museum of Zoölogy of the University of Michigan as follows: type slide, specimens mounted *in toto*, No. 263; paratypes mounted in sections, Nos. 267 and 268; paratypes in alcohol, No. 211.

DESCRIPTION

See Plates XXX–XXXI

Inasmuch as the morphology of the present species is in many respects similar to that of *Diplostomulum browni* Hughes, a species parasitic in snails at Douglas Lake, described by Hughes (1929), we consider it unnecessary to give a detailed description of it. *Diplostomulum gigas*, sp. nov., closely resembles *D. browni* in regard to the general form of the body (Figs. 1–4), the position and form of the oral sucker (*os*), acetabulum (*ac*) and hold-fast organ (*hf*), the structure of the digestive (*oe, int*), nervous (*spn, an, pn*), reproductive (*rf*) and excretory (Fig. 4) organs, so far as observed, and in the arrangement of cuticular spines, subcuticular muscle fibers (*cmf, lmf*) and parenchymal unicellular glands (*gc*).

Diplostomulum gigas differs from *D. browni* in that it is more than twice as large and the lateral suckers are more prominent in both living and preserved specimens. A layer of longitudinal muscle fibers (Fig. 1, *imf*) located in the parenchymal tissue ventral to the intestinal caeca (*int*) and between the posterior nerve trunks (*pn*) is plainly visible in cross-sections of *D. gigas* taken anterior to the acetabulum. Such muscle fibers were not found in cross-sections of *D. browni*. Large unicellular glands occur in the posterior part of the oral sucker. These were not found (but may be present) in *D. browni*.

Living specimens not subjected to cover-glass pressure vary in length from 0.5 mm. to 0.9 mm. and in width from 0.4 mm. to 0.45 mm. The length of the hind-body is about 0.1 mm., the diameter of the oral sucker from 0.08 mm. to 0.09 mm., the diameter of the acetabulum 0.09 mm. and the length and width of the pharynx 0.06 mm. and 0.023 mm., respectively. The principal measurements of 10 preserved specimens, mounted *in toto*, are shown in the accompanying table.

TABLE I

MEASUREMENTS IN MILLIMETERS OF TEN PRESERVED SPECIMENS OF *DIPLOSTOMULUM GIGAS* MOUNTED *IN TOTO*

	Minimum	Maximum	Average
Body, length.....	0.375	0.465	0.417
" width.....	0.270	0.375	0.302
Oral sucker, diameter.	0.042	0.056	0.050
Pharynx, length.....	0.028	0.042	0.035
" width.....	0.014	0.025	0.020
Oesophagus, length...	0.007	0.039	0.019
Acetabulum, diameter.	0.039	0.051	0.047
Hold-fast organ, diameter.....	0.070	0.098	0.083
Hind-body, length....	0.051	0.095	0.069
" " width....	0.088	0.140	0.111

Diplostomulum gigas differs from our specimens of *D. spathaceum* in that it is larger and more elongate and that the lateral suckers in preserved specimens are usually protruded as ear-like processes, whereas in *D. spathaceum* the lateral suckers are usually represented in preserved specimens by shallow cup-shaped depressions. In *D. gigas* vesicles (Fig. 3 *vcc*) containing calcareous concretions (Fig. 4 *cc*) are not found associated with the tubular portions (*tb*) of the urinary bladder (*ub*) as in *D. spathaceum*, as shown by Fraipont (1880, Pl. XVIII, Fig. 18). Unicellular glands in the parenchyma and the posterior part of the oral sucker such as occur in *D. gigas* have never been reported for *D. spathaceum*.

A definition of the larval group *Diplostomulum* and a comparative synopsis of the known species have been presented by Hughes (1929).

ACKNOWLEDGMENT

We wish here to express our grateful appreciation to Professor George R. La Rue of the Zoölogy Department and Director of the Biological Station, University of Michigan, by whom this study was suggested and under whom it has been conducted. We are

indebted to Professor L. Scheuring of the Bayerische Biologische Versuchsanstalt für Fischerei, München, for aid in securing specimens of *Diplostomulum spathaceum* (Rudolphi).

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EXPLANATION OF PLATES

ABBREVIATIONS

ac — acetabulum
acv — anterior transverse commissural excretory vessel
al — anterior lateral excretory vessel
an — anterior nerve
apt — anterior primary collecting excretory tubule
c — cuticula
cc — calcareous corpuscle
chf — cavity of hold-fast organ
cmf — circular muscle fibers
ep — excretory pore
et — excretory tubule
gc — unicellular gland
hb — hind-body
hf — hold-fast organ
imf — inner longitudinal muscle fibers
int — intestinal caecum
j — apparent place of union of primary excretory apparatus with reserve bladder
lc — lateral collecting excretory vessel
lmf — longitudinal muscle fibers
ls — lateral sucker
md — median dorsal excretory vessel
oe — oesophagus
os — oral sucker
pc — posterior transverse commissural excretory vessel
ph — pharynx
pl — posterior lateral collecting excretory vessel
pn — posterior nerve
ppt — posterior primary collecting excretory tubule
rf — fundament of reproductive organs
spn — supra-pharyngeal nerve commissure
tb — tubular portion of urinary bladder
ub — urinary bladder
vcc — vesicle occupied by calcareous corpuscle

PLATE XXX

Drawings made with the aid of a camera lucida. The guide line applies to both figures.

FIG. 1. Cross-section of *Diplostomulum gigas* through the fore-body anterior to the acetabulum

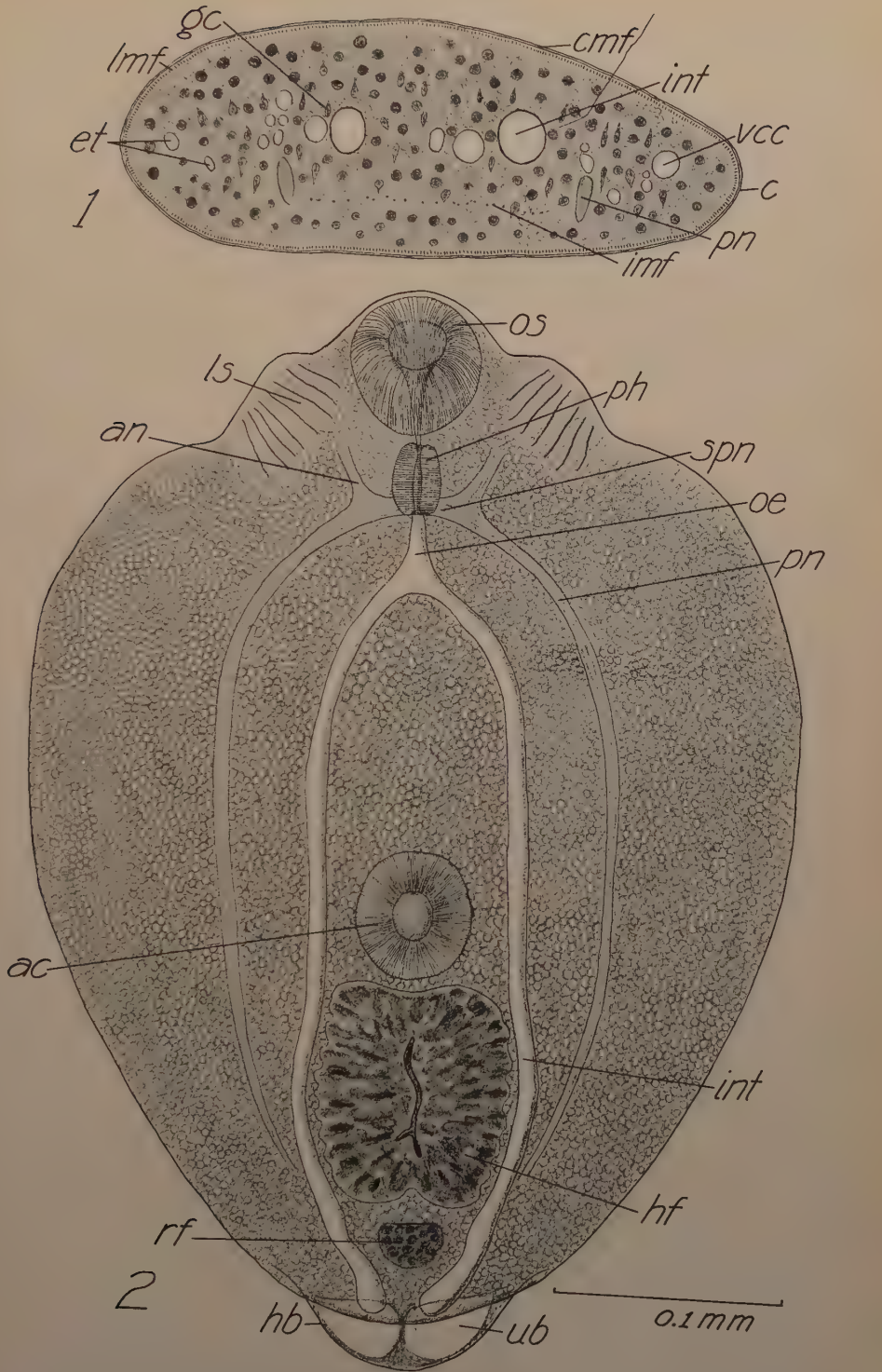
FIG. 2. Ventral aspect of *Diplostomulum gigas* drawn from a preserved specimen stained and mounted *in toto*

PLATE XXXI

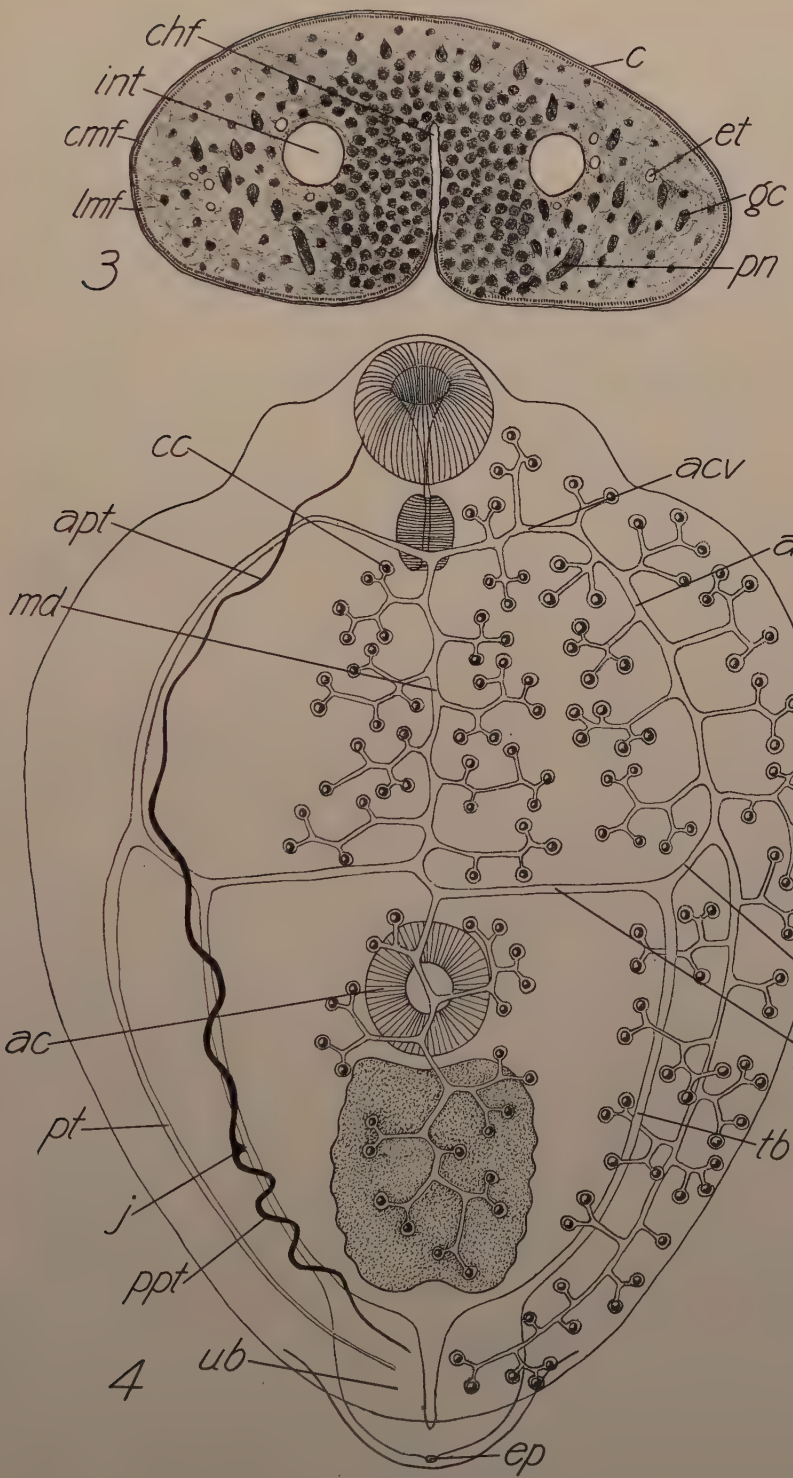
FIG. 3. Cross-section of *Diplostomulum gigas*, through the hold-fast organ. Drawn with the aid of a camera lucida to the same scale as Figures 1 and 2

FIG. 4. A semidiagrammatic representation, in dorsal view, of the excretory system of *Diplostomulum gigas* as seen in living specimens much flattened by cover-glass pressure

PLATE XXX



Diplostomulum gigas Hughes & Berkh., sp. nov.



Diplostomulum gigas Hughes & Berkh., sp. nov.

STUDIES ON THE TREMATODE FAMILY STRIGEIDAE (HOLOSTOMIDAE) No. XVI: *DIPLOSTOMULUM HURONENSE* (LA RUE)*

R. CHESTER HUGHES AND LUCILLA JANE HALL

A NEW species of strigeid metacercaria, *Diplostomulum huronense* (La Rue), determined by the feeding experiments performed by La Rue (1927, p. 27) and by Mr. J. P. Van Haitsma (unpublished)[1] to be the larva of *Diplostomum huronense* (La Rue), occurs in the eyes of the trout perch, *Percopsis omiscomaycus* Walbaum at Douglas Lake, Cheboygan Co., Michigan. Specimens were studied by us during the summers of 1926 and 1927. The presence of this parasite in the eyes of the trout perch was first reported by La Rue, Butler and Berkhout (1926, p. 285). The adult trematode is parasitic in the gut of the herring gull, *Larus argentatus* Pontoppidan (La Rue, 1927, p. 26).

During the summer of 1926, each of 28 trout perch, varying in length from 65 mm. to 96 mm. (average 82 mm.), contained from 2 to 189 (average 56) diplostomula in the eyes. In 24 of these fish, less than 9 per cent of the worms occurred within the lenses. During the summer of 1927, each of 9 trout perch, from 79 mm. to 95 mm. (average 86 mm.) in length, contained from 19 to 201 (average 80) worms in the eyes. About 18.5 per cent of these were found in the lenses. In no case were the diplostomula encysted.

Also during the summer of 1927, 15 yellow perch, *Perca flavescens* Mitchill, varying in length from 80 mm. to 260 mm. (average

* Contribution from the Biological Station and from the Department of Zoölogy, University of Michigan. This is the sixteenth of a series of studies on the family Strigeidae by Professor George R. La Rue, his students and associates.

[1] These studies by Mr. Van Haitsma are being prepared for publication in a later number of the present series.

115. 5 mm.) in length, were found to be parasitized with from 11 to 224 (average 60) diplostomula. In this host the worms were found exclusively in the vitreous humor. Although the diplostomulum found in the yellow perch is apparently morphologically identical with the one in the trout perch, the feeding experiments performed by La Rue (1927, p. 27) seem to indicate that the former is not the larva of *Diplostomum huronense*.

The method of study used for the present species is in all respects the same as that described for *Diplostomulum browni* by Hughes (1929).

Specimens of *D. huronense* studied in the preparation of this paper are catalogued in the parasite collection of the University of Michigan as follows: type slide, specimens mounted *in toto*, No. 271; paratypes mounted *in toto*, No. 272; paratypes mounted in section, Nos. 273 and 274; paratypes in alcohol, No. 207.

In regard to the effects of the parasite upon the host, it is probable that the worms, free-swimming in the vitreous humor, being small and transparent, have little effect upon the vision of the fish. The larvae within the lens generally occur, severally, in the larger ends of claviform, narrowly elongate, vacuities in the lens substance and with the oral sucker adjacent to the larger end of the space. These spaces may be found in any part of the lens. Never are the larvae massed in the postero-mesial portion of the lens in the manner described for *Diplostomulum gigas* (Hughes and Berkhout 1929, p. 483; nor do the lenses appear clouded. The shape of the vacuities and the position of the worms within them suggest that the growing larva literally eats its way through the lens substance, leaving an ever-widening trail behind it. This assumption is supported by the fact that the digestive apparatus of the organism is invariably filled with granules of a solid highly refractive substance, probably lens material. Moreover, the pointed ends of the vacuities are directed toward the periphery of the lens. These vacuities, situated chiefly in the cortical portion of the lens and filled with a limpid fluid, doubtless impair the vision of the host. Considering, however, the small numbers of worms found within the lens, the damage done to vision is probably a factor of negligible importance, the chief menace to the welfare

of the host being, in all probability, in the nature of mechanical injuries incident to the penetration of the cercariae. The effects of penetrating furcocercous (probably strigeid) cercariae upon fishes have been studied by Blochmann (1910), Fuhrmann (1916) and Szidat (1924 and 1927). Szidat (1924) studied the penetration of his *Cercaria C* into *Leuciscus rutilus* and observed its development into *Diplostomulum spathaceum* (Rudolphi).

In structure and behavior *Diplostomulum huronense* (Pl. XXXII) closely resembles *Diplostomulum browni* Hughes (1929), parasitic in the snail, *Lymnaea emarginata angulata* Sowerby, at Douglas Lake, and *Diplostomulum gigas* Hughes and Berkhout (1929), parasitic in the lenses of the common sucker *Catostomus commersonnii* Lacépède, also at Douglas Lake. Indeed the present species is so similar to *D. gigas* that we consider it superfluous to give a detailed account of its anatomy. *D. huronense* differs from *D. gigas* in the following respects: (1) it is considerably smaller; (2) in preserved specimens the lateral suckers are not infrequently withdrawn in the form of deep sac-like cavities (Pl. XXXII *cls*), a condition seldom seen in preserved specimens of *D. gigas;* and (3) it occurs chiefly in the vitreous humor, rather than in the lenses of the eyes infected.

Plates XXXII–XXXIII show the general appearance, in ventral view, of *Diplostomulum huronense* in the preserved and living conditions, respectively.

Owing to the fact that the animals were almost constantly in motion it was difficult to make satisfactory measurements of living specimens. We endeavored to measure the length and width of the body in states of extension, contraction and relaxation. The principal measurements obtained from 10 living specimens not under cover-glass pressure are shown in Table I and those of 10 preserved specimens mounted *in toto* in Table II.

TABLE I

MEASUREMENTS IN MILLIMETERS OF TEN LIVING *DIPLOSTOMULUM HURONENSE*, NOT SUBJECTED TO PRESSURE

	Length			Width		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Body,						
extended..	0.45	0.60	0.50	0.10	0.15	0.12
at rest....	0.35	0.43	0.37	0.18	0.22	0.21
contracted	0.28	0.34	0.25	0.21	0.30	0.25
Hind-body..	0.080	0.140	0.100	0.080	0.100	0.090
Oral sucker.	0.040	0.050	0.040	0.028	0.040	0.040
Pharynx....	0.035	0.040	0.040	0.026	0.028	0.028
Acetabulum.	0.035	0.040	0.040	0.040	0.050	0.040
Hold-fast						
organ....	0.050	0.080	0.070	0.070	0.080	0.080

TABLE II

MEASUREMENTS IN MILLIMETERS OF TEN *DIPLOSTOMULUM HURONENSE*, PRESERVED AND MOUNTED *IN TOTO*

	Length			Width		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Body.....	0.226	0.317	0.257	0.155	0.219	0.178
Oral sucker.	0.031	0.039	0.036	0.031	0.039	0.036
Pharynx....	0.017	0.031	0.021	0.014	0.017	0.017
Acetabulum.	0.028	0.039	0.033	0.035	0.053	0.040
Hold-fast						
organ....	0.028	0.077	0.050	0.053	0.088	0.069

For purposes of comparison we have made use of several specimens of *Diplostomulum spathaceum* (Rudolphi) found in the lenses of *Cobitis barbatula* from the vicinity of Breslau and presented to Professor La Rue by Professor L. Scheuring of München. These

specimens were studied both in sections and in whole mounts. We find that *Diplostomulum huronense* differs from these specimens of *D. spathaceum* in that the body is generally more elongate and the lateral suckers more prominent. Fraipont (1880, Pl. XVIII, Fig. 18) shows that in *D. spathaceum*, vesicles containing calcareous corpuscles stand in direct communication with the tubular portions of the urinary bladder, a condition not found in *D. huronense*, *D. browni* or *D. gigas*. Unicellular glands such as occur in the parenchyma and posterior part of the oral sucker of *D. huronense* and *D. gigas* have not been reported for *D. spathaceum*. Our specimens of *D. spathaceum* were not fixed in a manner that would enable us to determine whether such glands are present.

A comparative synopsis of the known species of diplostomula has been presented by Hughes (1929).

ACKNOWLEDGMENTS

We wish here to express our grateful appreciation to Professor George R. La Rue of the Zoölogy Department and Director of the Biological Station, University of Michigan, by whom this study was suggested and under whom it has been conducted. We are indebted to Professor L. Scheuring of the Bayerische Biologische Versuchsanstalt für Fischerei, München, for aid in securing specimens of *Diplostomulum spathaceum* (Rudolphi).

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EXPLANATION OF PLATES

The following abbreviations are used: *ac*, acetabulum; *an*, anterior nerve; *cls*, cavity of lateral sucker; *hf*, hold-fast organ; *int*, intestinal caecum; *ols*, orifice of cavity of lateral sucker; *os*, oral sucker; *ph*, pharynx; *pn*, posterior nerve trunk; *rf*, fundament of reproductive organs; *spn*, supra-pharyngeal nerve commissure; *ub*, dextral half of urinary bladder; *hb*, hind-body; *ls*, lateral sucker; *m*, mouth; *mpl*, postero-ventral lip of fore-body; *pph*, pre-pharynx.

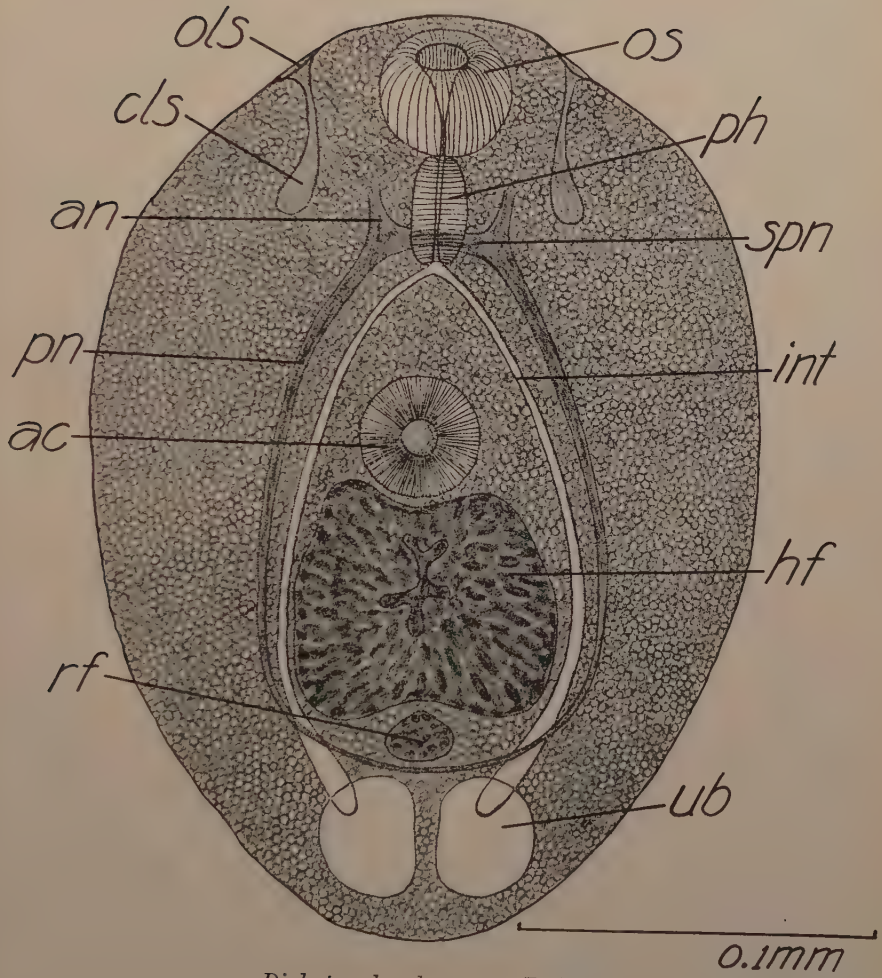
PLATE XXXII

Ventral view of *Diplostomulum huronense* (La Rue), drawn with the aid of a camera lucida from a preserved specimen stained and mounted *in toto*. The individual has the lateral suckers retracted in the form of deep sac-like cavities, a condition frequently, but not always, found in preserved specimens.

PLATE XXXIII

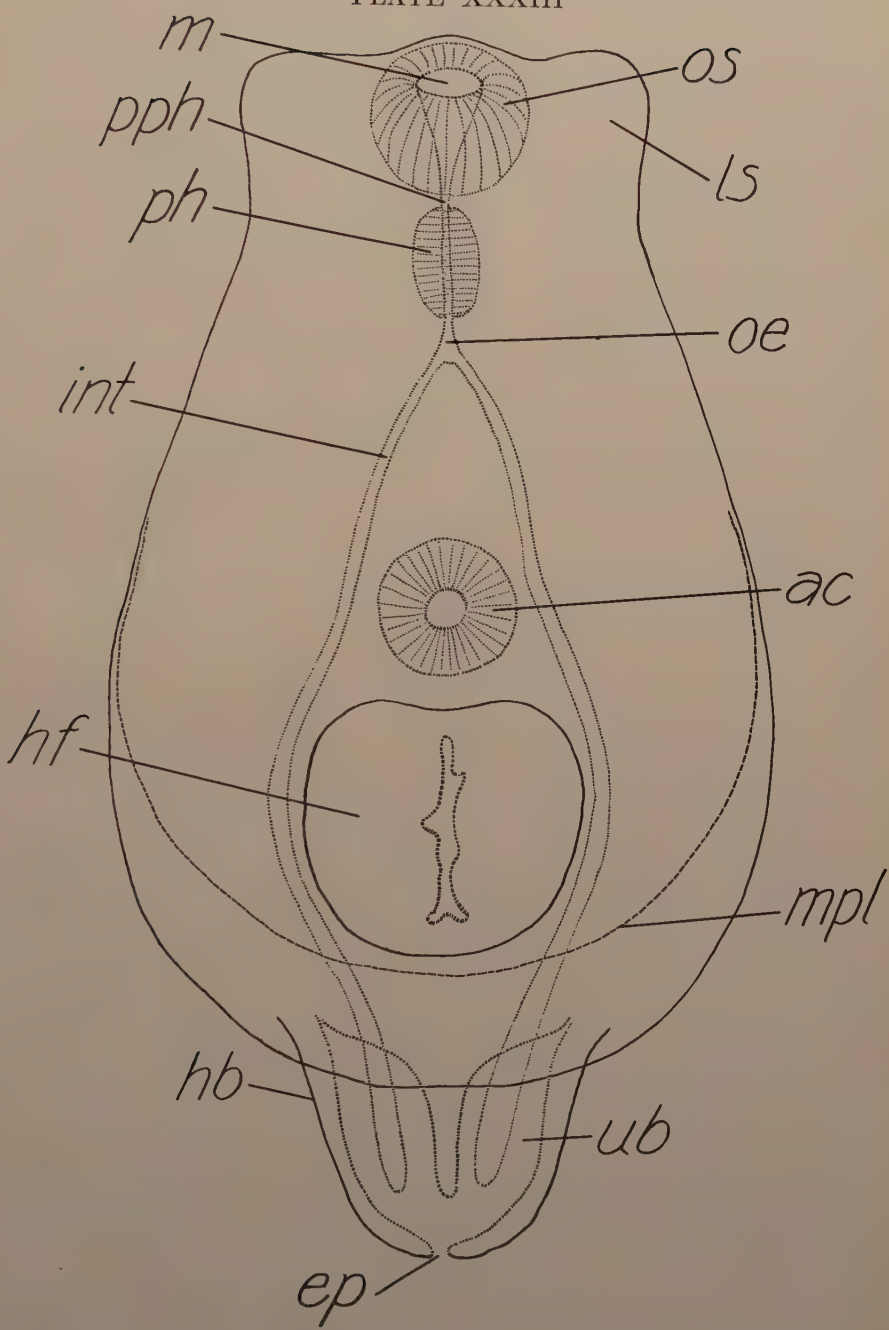
Ventral view of *Diplostomulum huronense*, drawn free-hand from a living specimen. The lateral suckers usually appear as indicated in this figure.

PLATE XXXII



Diplostomulum huronense (La Rue)

PLATE XXXIII



Diplostomulum huronense (La Rue)

STUDIES ON THE TREMATODE FAMILY STRIGEIDAE (HOLOSTOMIDAE) No. XVII: *TETRACOTYLE FLABELLIFORMIS* FAUST*

R. CHESTER HUGHES

THE parasites upon which this study has been made differ in several important respects from *Cercaria flabelliformis* as originally described (Faust, 1917 a, p. 111, Fig. 4). It seems probable, however, for reasons which are discussed later, that the two forms are identical. The structural differences found in my studies, as compared with the descriptions by Faust, are of sufficient magnitude to warrant a redescription of the species.

MATERIAL AND METHODS

The material upon which this study is based consists of a cotype specimen of *Cercaria flabelliformis* Faust, stained and mounted *in toto*, and a collection of tetracotyles taken by me from snails at Douglas Lake, Cheboygan County, Michigan, during the summer of 1927. The cotype specimen was submitted by Faust with his doctor's thesis to the Department of Zoölogy of the University of Illinois, and, through the courtesy of Professor Henry B. Ward to Professor La Rue, it has been made available to me.

An examination of 13 specimens of *Lymnaea stagnalis perampla* Walker collected from Douglas Lake showed 9 to be infected with from 5 to 765 (average 118) tetracotyles per snail. A single specimen of *Planorbis campanulatus* Say contained 23 parasites of apparently the same species. Alcoholic specimens taken from each

* Contribution from the Biological Station and from the Department of Zoölogy, University of Michigan. This is the seventeenth of a series of studies on the family Strigeidae by Professor George R. La Rue, his students and associates.

of these hosts have been deposited as lots numbered 213 and 203, respectively, in the parasite collection of the Museum of Zoölogy of the University of Michigan. In every specimen the worms occurred scattered through the soft parts (liver and reproductive gland) of the host. In *Planorbis* several specimens were found in the sporocysts of other trematodes, a condition not observed in *Lymnaea*, although the latter sometimes harbored parthenitae. In general the specimens taken from *Planorbis* have the hind-body a little broader and less distinctly set off from the fore-body, differences, however, which are seemingly too slight to warrant the establishment of a new species for them. In the type host, *Physa gyrina* Say from Corvallis, Montana, the parasite was sometimes found in the rediae of other trematodes (Faust, 1917 a, p. 111).

The method employed for the fixation of material and the preparation of slides is the same as that used in my study of *Tetracotyle pipientis* Faust (Hughes, 1928, p. 43). Here again the same advantages were found in the study of living material. The cotype specimen was treated with the same stain as that used in my preparations.

THE CYST

During the early part of its development the tetracotyle is free in the tissues of the host. The more mature individuals, however, are always encysted. The nature of the cyst is very peculiar and deserves special consideration. In *Tetracotyle cornuta* (Rudolphi) (*T. typica* Diesing), a closely related European species, the cyst has long been a subject of controversy. In living material of the present form the cyst consists of a thick layer of gelatinous substance closely adherent to the cuticle of the parasite and with perforations adjacent to the excretory pore, and the external openings of the oral sucker, lateral suckers and the cavity of the hold-fast organ. Steenstrup (1845, p. 80) stated that when fully grown the Distomata (tetracotyles) "are covered by a very thick cuticle, appearing as if they were enveloped in a thick layer of inspissated albumen." Pagenstecher (1857, p. 32) spoke of the cyst as follows: "Trotz ihrer doppelten Umrisse kann man sie eigentlich nicht als Cysten bezeichnen, denn der zweite Umriss wird allein

von der abgelösten alten Haut des Thieres gebildet." Ercolani (1881, p. 287) wrote: "Che la grossa e diafana membrana che avvolge tutto l'animale, non sia una cisti, ma una dipendenza della pelle, è attestato dal fatto che essa aderisce non solo tenacemente su tutta la superficie del corpo dell' animale, ma che in corrispondenza del poro terminale deve rimanere aperta se lascia sfuggire i materiali contenuti nei numerose vasi excretori che si diramano nel parenchima del suo corpo." Finally, I quote from Mathias (1925, p. 20) as follows: "Le *T. tarda* Steenst. est la forme larvaire immobile d'un Holostomide, mais ce n'est pourtant pas un kyste comme c'est le cas général chez les Trématodes. En effet, un kyste véritable est caractérisé par une membrane d'enveloppe continue, hyaline, d'épaisseur variable, qui isole complètement la cercaire enkystée du milieu ambiant."

That this investiture of the mature *T. cornuta* is really a cyst was recognized by Henle (1835, p. 597), Diesing (1858, p. 366), De Filippi (1859, p. 215), Von Linstow (1894, p. 332) and Szidat (1924, p. 310). Faust (1917 a, p. 111), concerning *T. flabelliformis*, states that some of the parasites were encysted. My sections show clearly that the parasite is surrounded by a definite extra-cuticular membrane. A similar cyst has been described for *Adolescaria perla* Sinitsîn (a metacercaria parasitic in *Mytilus edulis* and *Venus sp.* in the Black Sea) by Sinitsîn (1911, p. 39) in the following words: "The cyst consists of a gelatinous, or even cartilaginous, membrane which lies close to the body of the *Adolescaria* with which it forms, technically speaking, a unit."[1]

Apertures in the cyst of *T. flabelliformis* adjacent to the excretory pore and the external openings of the oral and lateral suckers and the cavity of the hold-fast organ were not mentioned by Faust; such apertures, however, are clearly visible in the cotype specimen. An aperture adjacent to the excretory pore in the cyst of *T. cornuta* has been observed by many authors; Szidat (1924, p. 310, Fig. 8) also showed the presence of a canal in the wall of the cyst adjacent to the oral sucker.

[1] From a translation of the original Russian prepared under the direction of Professor Henry B. Ward by Mr. Alexis M. Bagusin, a Russian student of zoölogy at the University of Illinois.

The cyst is hyaline, non-cellular, and apparently of parasite origin; even when ruptured it adheres to the cuticle of the parasite and cannot be removed without injury to the latter. The wall of the cyst shrinks materially in the process of fixation, becoming a thin membrane (Fig. 1 *c*) closely applied to the surface of the parasite. This membrane does not interfere with staining *in toto*, differing in this respect, from the usual behavior of cysts of parasite origin. Whether the ability of stains to reach the parasite within the cyst depends entirely upon the presence of natural apertures in it, or, in part, upon its peculiar permeability, was not determined. The fact that the cyst wall shrinks in the process of fixation would seem to indicate that it is more or less permeable. In two living specimens, not under cover-glass pressure, the cysts were 0.018 mm. and 0.036 mm. thick.

THE PARASITE

Inasmuch as the present species closely resembles *Tetracotyle cornuta*, with which it may be identical and which has often been carefully described (see synopsis), it seems unnecessary to give a detailed account of its structure. Certain misinterpretations made by Faust, however, deserve consideration.

The eversion of the lateral suckers and the hold-fast organ in the form of lappets in the larva is doubtless an abnormal condition brought about by excessive imbibition of water, and not a property of maturity, as suggested by Faust (1917 b, p. 63, Pl. III, Fig. 40). In living specimens freshly removed from the host the walls of these cavities are never everted. In dead and water-soaked specimens, however, they are generally protruded.

The reproductive system is represented by a single median poorly differentiated mass of cells (Fig. 1 *rf*) located in the anterior part of the hind-body. The reproductive system, according to Faust (1917 b, p. 45), comprises ovary, oviduct, uterus, genital pouch, vitelline glands and testes fairly well developed. In reality most of the structures thus described are lobes of the irregularly shaped hold-fast organ (Fig. 1 *hf*) and the ramifications of the cavity (*chf*) among them. The acetabulum was considered to be a primitive genital pore (Faust, 1917 b, Pl. III, Fig. 38). Similar

misinterpretations made by Faust (1917 b, p. 64) concerning the reproductive system of *Tetracotyle pipientis* were corrected by Hughes (1928, p. 46).

The reserve bladder is similar to that described by Hughes (1927, p. 257) for a tetracotyle found in the pericardial cavity of *Stizostedion canadense griseum* De Kay[2] as "an irregular continuous coarse-meshed network of spaces, not in the form of definite vessels" filled with (p. 256) "a thin hyaline fluid, containing calcareous granules of various sizes, which move freely in *any direction* in response to pressure or movements of the body." The reserve bladder, therefore, does not comprise a regular system of definite vessels, as suggested by Faust (1922, p. 80), based on his description (Faust, 1917 b, p. 37, Pl. III, Fig. 39). Similar errors made by Faust (1917 b, p. 64) concerning the excretory system of *Tetracotyle pipientis* were corrected by Hughes (1928, p. 48). In addition to the granules freely moving in the spaces of the reserve bladder, others are found confined to more or less isolated pockets adjacent to the body-walls. These granules, however, less regular in shape and size than in *T. pipientis*, show a tendency to be arranged in groups of some 4 or 5 in a row, the ensemble of these groups constituting a very irregular subcuticular net-work. Oil droplets such as were found in *T. pipientis* (Hughes, 1928, p. 49) do not occur. A few flame cells and scattered tubules of the primary excretory apparatus were observed, but not in sufficient number and detail to give a definite idea of their arrangement.

Five living specimens from *Lymnaea stagnalis perampla*, freshly removed from the host and not under cover-glass pressure, varied in length from 0.298 mm. to 0.407 mm. (average 0.366 mm.) and in width from 0.255 mm. to 0.291 mm. (average 0.262 mm.). Faust (1917 a, p. 111) found that "mature" specimens were somewhat larger than these measurements indicate. He regarded as mature, however, specimens in which the lateral suckers were everted and which were therefore in an abnormally distended condition. The following measurements were determined from a few (1 to 3) living specimens under cover-glass pressure: oral

[2] A description of this tetracotyle is being presented in another paper of the present series.

sucker, from 0.054 mm. to 0.060 mm. in diameter; acetabulum, from 0.048 mm. to 0.060 mm. in length and from 0.057 mm. to 0.060 mm. in width; mouth of the cavity of the hold-fast organ (Fig. 1 *ohf*), from 0.015 mm. to 0.063 mm. (average 0.041 mm.) in width; external opening of lateral sucker (*ols*), 0.030 mm. in length. The principal measurements of ten preserved specimens mounted *in toto* are shown in the accompanying table.

TABLE I

PRINCIPAL MEASUREMENTS IN MILLIMETERS OF TEN *TETRACOTYLE FLABELLIFORMIS*, PRESERVED AND MOUNTED *IN TOTO*

	Minimum	Maximum	Average
Body, length	0.218	0.282	0.253
" width	0.162	0.212	0.191
Hind-body, length	0.070	0.095	0.081
" width	0.115	0.151	0.133
Oral sucker, diameter	0.042	0.053	0.047
Acetabulum, diameter	0.035	0.049	0.043
Hold-fast organ, diameter	0.077	0.098	0.086

DISCUSSION

The worms upon which this study has been made are regarded as being identical with *Tetracotyle flabelliformis* Faust, since in general form and size they conform to Faust's descriptions and in those details wherein they differ from his descriptions they agree with the cotype specimen. Furthermore, ample reasons have been given for considering certain statements in Faust's descriptions to be in error; these points have already been discussed.

A number of names for tetracotyles found in invertebrate hosts (snails and leeches) occur in the literature, but in general not enough is known of these forms to distinguish them from *Tetracotyle cornuta* (Rudolphi), the larva of *Strigea cornuta* (Rudolphi) according to Szidat (1927, p. 400). *Tetracotyle orientalis* Faust, demonstrated by Faust (1922, pp. 81, 82) to be the larva of *Cyathocotyle orientalis* Faust, constitutes an exception to this state-

ment. A tentative list of all known and supposed species of tetracotyles parasitic in invertebrate hosts is given in the following synopsis. Synopses of tetracotyles parasitic in fishes and other vertebrates are being presented in other papers of the present series.

SYNOPSIS OF TETRACOTYLES PARASITIC IN INVERTEBRATES

1. *Tetracotyle hirudinum* (Diesing) Mataré

SYNONYMY:

Cercarienformen, Distoma, cercarienartige — aus der Matrix des Blutegels	Henle (1835, pp. 587, 598, 608, respectively)
"Distom" (from) *Hirudo vulgaris L.*	Creplin (1841, p. 79)
Heptostomum hirudinum	Schomburgk (1844, p. 166)
Heptastomum Hirudinum Schomburgk	Diesing (1850, p. 418) *ex parte*
Heptastomum Hirudinum Schomburgk	Diesing (1858, p. 370)
Tetracotyle hirudinum	Mataré (1910, p. 496)
Tetracotyle (Heptastomum) hirudinum (Schomburgk)	Faust (1918 b, p. 75)

This form, first found and briefly described by Henle (1835, p. 587, Taf. XIV, Fig. 7a), was again briefly described by Diesing (1850, p. 418, and 1858, p. 370, Taf. II). Although Diesing's figures are poor and have the anterior and posterior ends of the worms confused, they show typical tetracotyliform structures. Monticelli (1888, p. 92), Brandes (1890, p. 578) and Braun (1892, p. 795) recognized *Heptastomum* to be a larval holostome; Von Linstow (1894, p. 330) considered it identical with *Tetracotyle cornuta*. It has been reported from *Nephelis vulgaris* and *Clepsine complanata*.

2. *Tetracotyle cornuta* (Rudolphi) mihi

SYNONYMY:

Distoma (from) *Planorbis corneus*	Henle (1835, p. 597)
Schmarotzer im Sporenschlauche der Cercaria armata und echinata	Von Siebold in Burdach (1837, p. 195), according to Diesing (1858, p. 366)
Distoma (of) *Cercaria armata Siebold*	Steenstrup (1842, p. 46)
Distoma tarda	Steenstrup (1842, p. 75), *ex parte*
Heptastomum Hirudinum Schomburgk	Diesing (1850, p. 418), *ex parte*

Tétracotyle	De Filippi (1855, p. 351)
Tetracotyle Limnaei	Pagenstecher (1857, p. 32)
Distoma tardum	Claparède (1858, p. 103)
Tetracotyle typica Diesing	Diesing (1858, p. 366), *ex parte*
Tetracotyle typica Dies. (*e. p.*)	Von Linstow (1877, p. 193)
Del Tetracotile De Filippi	Ercolani (1881, p. 284)
Tetracotyle tipica, Diesing	Leidy (1891, p. 416) ?
Tetracotyle tarda Steenst.	Mathias (1925, p. 16)
Tetracotyle tarda (Steenstrup) Mathias	Hughes (1927, p. 255)
Tetracotyle typica de Filippi	Szidat (1927, p. 401)

First found and briefly described by Henle (1835, p. 597), this tetracotyle has since been described in more or less detail by Steenstrup (1842, pp. 46, 76; Pl. III, Figs. 5–6), Von Siebold (1843 a, p. lviii, and 1843 b, p. 325), De Filippi (1855, p. 351; Pl. II, Fig. 25, and 1859, pp. 213–219; Pl. III, Figs. 24–31), Moulinié (1856; Pl. VII, Fig. 19), Pagenstecher (1857, p. 32; Taf. III, Figs. 15–18), Diesing (1858, p. 366), Ercolani (1881, p. 284, Tav. II, Figs. 16–18), Von Linstow (1894, p. 330, Taf. XXII, Figs. 1–8), Lühe (1909, p. 169), Faust (1918 b, p. 76), Szidat (1924, p. 306; Figs. 4–9) and Mathias (1925, p. 17; text Figs. 2, 3; Pl. I, Figs. 2–4; Pl. II, Figs. 1, 2, 4, 5, 6, 10). It has been reported from various species of *Lymnaea*, *Planorbis* and *Paludina* in Europe. In North America Leidy (1891, p. 416) and in South America Lutz (1921) have reported the occurrence of tetracotyles which they identified with the present species. In this synopsis these reports are discussed in connection with *Tetracotyle flabelliformis* and *T. molluscipeta*, respectively.

T. cornuta often occurs in, and associated with, the parthenitae of other trematodes, to which it was considered to be genetically related by Steenstrup (1845, p. 79) and De Filippi (1855, p. 352; 1857, p. 427; and 1859, p. 217). This idea, already opposed by Henle (1835), Von Siebold (1843 a, 1843 b), Moulinié (1856, p. 150) and Pagenstecher (1857), was shown to be entirely untenable by Ercolani (1881, p. 286). Ercolani (p. 288) further succeeded in demonstrating by feeding experiments that in ducks the tetracotyles develop into adult holostomes which he identified, in error, as *Holostomum erraticum* Dujardin. Von Linstow (1877, p. 195) studied the development of two-eyed miracidia from the eggs of *Holostomum cornucopia* Molin. A superficial resemblance between

these larvae and tetracotyles led him to suppose that tetracotyles develop directly from eggs. Supported by this assumption of Von Linstow and the work of Ercolani, Leuckart (1889, p. 163) advanced the theory that holostomes are "metastatic" trematodes, having an alteration of hosts but not of generations. This theory, accepted by Brandes (1890, p. 570) and Braun (1892, p. 796), held sway until Lutz (1921) discovered that tetracotyles develop from furcocercous cercariae produced in thread-like sporocysts parasitic in snails. The entire life-cycle of the tetracotyle was worked out by Mathias (1922 and 1925). He classified the adult as *Strigea tarda* Steenstrup. Szidat (1924) observed the penetration of his *Cercaria A* into *Lymnaea palustris* and carefully studied its transformation into *Tetracotyle cornuta*. Szidat (1927, p. 400) demonstrated that the adult form should be identified with *Strigea cornuta* (Rudolphi), described as *Amphistoma cornutum* by Rudolphi (1809, p. 343). That the reserve bladder of *T. cornuta* is similar to that of *T. flabelliformis* is suggested by two figures of Von Linstow (1894, Taf. XXII, Figs. 6–7). The structures referred to as "Plasmastränge" are probably spaces of the reserve bladder. The structures interpreted by De Filippi (1855, Pl. II, Fig. 25) to be branches of the intestinal caeca are probably parenchymal strands interspersed in the reserve bladder.

3. *Tetracotyle flabelliformis* Faust

SYNONYMY:

? Tetracotyle tipica, Diesing	Leidy (1891, p. 570)
Cercaria flabelliformis	Faust (1917 a, p. 111)
Cercaria (Tetracotyle) flabelliformis Faust	Faust (1917 b, p. 37)
Tetracotyle flabelliformis	Faust (1922, p. 80)

Leidy (1891, p. 570) was the first to report the occurrence of a tetracotyle parasitic in snails in this country. He identified specimens from *Lymnaea catascopium* and *Physa heterostropha* as *Tetracotyle tipica*. Faust (1917 a, p. 111, and 1917 b, p. 63) considered that the tetracotyles were produced by the parthenitae of other trematodes, in which and associated with which they were often found.

4. *Tetracotyle iturbei* Faust

SYNONYMY:

Redia of Schistosomum mansoni	Iturbe and González (1917, p. 10)

This form, parasitic in *Planorbis guadalupensis* in Venezuela, was first found and figured by Iturbe and González (1917, Figs. 1–10) as rediae of *Schistosomum mansoni*. This material was redescribed as *Tetracotyle iturbei* by Faust (1918 a, p. 109, and 1918 b). Through the courtesy of Professor H. B. Ward of the University of Illinois to Professor La Rue, I have had opportunity to examine cotype material of this parasite and I find it to be very similar to, if not identical with, *Tetracotyle flabelliformis*. In regard to generative organs Faust made errors comparable to those in his descriptions of *T. flabelliformis*, which are discussed in the first part of this paper. The probability that certain interpretations were erroneous was suggested by Szidat (1924, p. 311) and Ashworth and Bannerman (1927, p. 162).

5. *Tetracotyle molluscipeta* (Lutz) mihi

SYNONYMY:

"Tetracotyle . . . typica"	Lutz (1921, p. 128)

Lutz (1921, p. 126) found a furcocercous cercaria, which he called *Dicranocercaria molluscipeta*, produced by parthenitae parasitic in snails. The cercaria was described in general terms which applied also to two other closely related species. He found, however, that *D. molluscipeta* differed from the other two species in certain structural details and in that it chose to penetrate snails (species of *Physa*, *Planorbis* and *Spirulina*) to further its development. In these snails the worms developed into encysted larvae which he identified as *Tetracotyle typica* and which, when fed to ducks, became adult holostomes, identified by him as *Strigea tarda* (Steenstrup). The fact that *Anas moschata* in Brazil is known to harbor two species of holostomes, *Strigea sphaerocephalum* (Westrumb) and *Strigea graciliformis* Szidat, neither indigenous to Europe, suggests a possibility that the *Strigea* obtained by Lutz, in the experiment mentioned above, may not be

identical with any European species. For this reason the specimens identified by Lutz as *Tetracotyle typica* are here listed, provisionally, as a separate species, under the name of the cercaria from which they were developed. Lutz's discussion of this species, however, can hardly be regarded as a description.

6. *Tetracotyle bdellocystis* (Lutz) mihi.

Another of the three species of furcocercous cercariae mentioned in the preceding paragraph (Lutz, 1921, p. 126), *Dicranocercaria bdellocystis*, was observed to penetrate into leeches (species of *Haementeria* and *Hemiclepis*) in which it became a tetracotyle. A description of the tetracotyle was not given.

7. *Tetracotyle orientalis* Faust

This species, parasitic in *Vivipara lapillorum* Heude, near Peking, China, was described by Faust (1922, p. 79, Pl. IX, Fig. 1, and Pl. X). In general form it resembles *T. flabelliformis*, from which it differs in having the following characters: (1) primordia of vitellaria, (2) intestinal caeca, short, (3) cyst wall not adherent to cuticle (since the parasite moves "freely within the cyst"). A careful study was made of the excretory system, particularly of the *primary excretory apparatus*. By a feeding experiment it was determined that the tetracotyle is the larva of *Cyathocotyle orientalis* Faust, parasitic in ducks (*Anas boschas*).

ACKNOWLEDGMENTS

I wish here to express my grateful appreciation to Professor George R. La Rue of the Biological Station and the Department of Zoölogy, University of Michigan, by whom this study was suggested and under whom it has been conducted.

I am indebted to Professor Henry B. Ward of the Department of Zoölogy of the University of Illinois, through whose courtesy to Professor La Rue I have had an opportunity to study cotype material of *Tetracotyle flabelliformis* Faust and *Tetracotyle iturbei* Faust.

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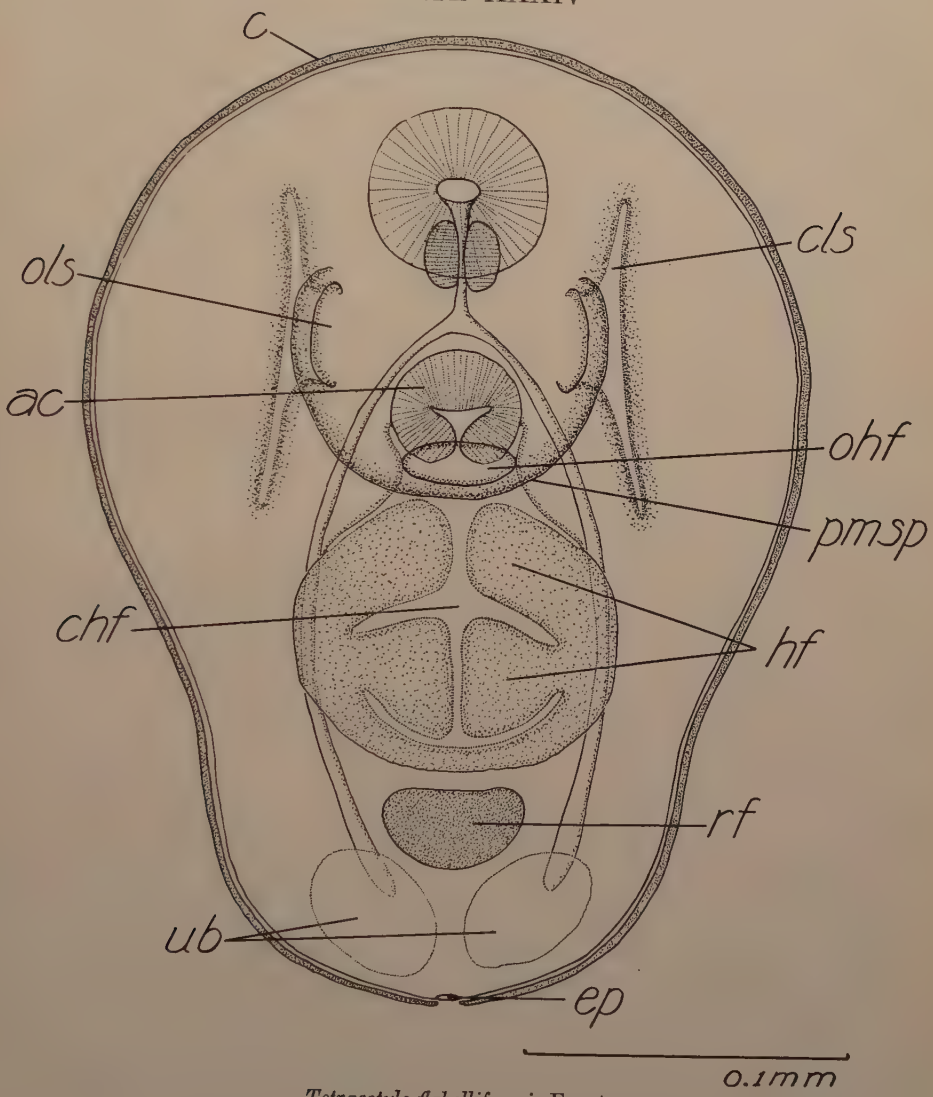
EXPLANATION OF PLATE XXXIV

The following abbreviations are used: *ac*, acetabulum; *c*, cyst wall; *chf*, cavity of hold-fast organ; *cls*, cavity of lateral sucker; *ep*, excretory pore; *hf*, hold-fast organ; *ohf*, external meatus of hold-fast organ; *ols*, orifice of lateral sucker; *pmsp*, posterior margin of suctorial pocket; *rf*, fundament of reproductive organs; *ub*, urinary bladder.

Tetracotyle flabelliformis from *Lymnaea stagnalis appressa*, ventral view of a preserved specimen mounted *in toto*, drawn with the aid of a camera lucida. The digestive caeca, which are not visible in whole mounts, are added for the sake of clarity.

PLATE XXXIV



Tetracotyle flabelliformis Faust

STUDIES OF DEVELOPMENTAL ANOMALIES IN THE DESCENDANTS OF X-RAYED MICE

WILLIAM S. MURRAY

PART I: GENETIC BEHAVIOR

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INTRODUCTION

DURING 1921, Drs. C. C. Little and H. J. Bagg, in an attempt to change the character of the germ-plasm in a stock of colored mice, treated a selected group of these animals with a light dose of X-rays. The early results of these irradiations were reported by these co-authors in their papers of 1923 and 1924. In these reports they described four structural defects which were apparently caused by the treatment of X-rays:

1. An eye abnormality;
2. An abnormality of the pigment and hair of the back which they called "saddled";

3. A kidney abnormality (Bagg, 1923);
4. An abnormality of the feet.

Part I of the present paper is an attempt to describe the form and inheritance of the foot abnormality, which was first reported by the original workers. Part II is the record of a study made to ascertain whether observable structural changes in the motor mechanism of the spinal cord could be correlated with the foot abnormalities. Brief reference will also be made to eye and kidney abnormalities.

The author is greatly indebted to Drs. C. C. Little and G. Carl Huber for their untiring help and encouragement in the preparation of this work as a whole; and to Dr. R. E. McCotter for his advice in making the cell counts, to Dr. P. S. McKibben for his help with the photography, and to Miss Elizabeth Fekete for her sketches of the abnormalities.

HISTORICAL

Since the theory of pangens was first set forth by Darwin, the literature is replete with records of attempts to change the germ-plasm. The agents used in these efforts have been many and varied, ranging from specific mutilations — Weismann (1889), Charrin (1902), Delage[1] (1903) — to changes in environment and the use of chemical and physical agents. The methods of administering these treatments have been as numerous and diverse as have been the types of treatment themselves.

Since the rebirth of Mendelism in 1900, Lamarckism suffered a relapse until Guyer and Smith (1918, 1920, 1920 a, 1921, 1922, 1922 a, 1924), Stockard (1913, 1916, 1921, 1923, 1923 a, 1924), Stockard and Craig (1912), and Stockard and Papanicolaou, with their work on lens antibodies and alcohol, respectively (1916, 1918), brought up the question anew.

Guyer and Smith contend that by introducing a specific antibody (lens protein of the rabbit) into the blood of a fowl, they are able to bring about changes in the fowl which encourage the building up of antibodies which have a tendency to protect the birds

[1] A complete history of the early theories is given by Delage, Y., Paris, 1903, *L'Hérédité et les grands Problèmes de la Biologie Générale.*

against the foreign proteins. If, then, this antibody is taken from the fowl and introduced into the blood-stream of a pregnant rabbit, it appears to act directly upon the optic lenses of the developing fetuses and causes them to have abnormal eyes. In addition to this, Guyer and Smith state that these antibodies evidently have a direct effect upon the germ-plasm of the embryos in that the same deformity which occurs in the embryos of the treated rabbits is handed down to their progeny as a Mendelian recessive. Stockard finds much the same sort of deformity in the young of guinea pigs which were subjected to alcohol fumes for long periods. He also claims that the young of alcoholized males have abnormal eyes and that the germ cells are affected, inasmuch as these abnormal guinea pigs pass on this abnormality to their young.

The most popular of the physical agents that have been used in attempts to change the germ-plasm have been radium emanation and X-rays. These agents have been used largely because of ease of application and the very definite abnormalities which they are capable of producing. They also have interesting bearings upon therapeutic methods in medicine.

The early work with radio-active substances was correlated with the production of parthenogenesis and monstrosities. G. Hertwig (1913) found that by treating the sperm of *Rana fusca* from two to three hours between capsules of mesothorium, he could obtain the same results in the eggs fertilized by the radiumized sperm as Bataillon (1910) had obtained by sticking the mature ovum of the frog with a fine platinum needle. In both cases the egg developed normally and gave rise to swimming tadpoles. O. Hertwig (1913), repeating the work of his son upon the eggs and sperm of *Triton vulgaris* and *Salamandra maculata*, showed that many of the eggs failed to become fertilized; some showed polyspermy and only a few developed normally. He concluded from the data that the chromatin material of the sperm had been broken down by the effect of the radium, and that the same condition was obtained in the pronucleus of the treated eggs. The work of P. Hertwig has also been outstanding in this field. These findings of the Hertwigs bore out the observations of many earlier work-

ers — Bohn (1903), Danysz (1903), Perthes (1904), Bordier (1905), and Thies (1905) — all of whom had reported abnormal development and monstrosities in various forms treated with radium and X-rays. Later, Tur (1911), Lacassagne and Coutard (1923), and Baldwin (1919) reported similar deformities in the embryos of birds and the larvae of frogs treated with X-rays. In the same year, 1911, Loeb and Bancroft (1911) reported that they had obtained several mutants in *Drosophila* which had been treated with X-rays. Later, Bagg (1920, 1922) found that in mammals radium emanation had a selective action upon fast-growing tissues, and that it caused very decided developmental arrests in the nervous and reproductive systems of animals exposed to the rays near the end of pregnancy. He found that radiation produced extravasations of blood in the subcutaneous tissues of the developing embryos and that the radium emanation possibly had a specific effect upon endothelial tissues lining the blood vessels. Bailey and Bagg (1923) found that radiation before fertilization disturbed and arrested the development of mammals, leading to the formation of monsters which conform to a general type. In these experiments they found a pronounced disturbance in the central nervous system and a marked tendency toward progressive loss of fertility, thus confirming the work of Bohn, Perthes, the Hertwigs, Tur, Bordier, and Baldwin. They also ascertained that irradiation during pregnancy caused disturbed abnormal development, absorption, sterility, and lesions of the central nervous system, as well as blood vascular disturbances in the embryos. These observations were also made by Hippel and Pagenstecher (1907), Regaud, Nogier, and Lacassagne (1912), Lengfellner (1906), Krukenberg (1909), Cohn (1909), Bagg (1922), Hanson (1923), Lacassagne and Coutard (1923).

Mavor (1921, 1921 a, 1922, 1923, 1923 a), after treating *Drosophila melanogaster* with X-ray irradiation, found that it might cause non-disjunction of the "X" chromosomes during either the first or the second maturation division, producing in this way by non-disjunction "exceptional" males and females in greater number than ordinarily occurs among breeding animals. This work was later confirmed by Anderson (1924).

Bagg (1920) found that repeated injections of radio-active salts into rats brought on marked changes in the content of the blood-stream, together with fatty degeneration of the liver and hemorrhage of all organs.

More recently, Muller (1927), working with *Drosophila*, found that "the general frequency of gene mutation may be raised at will to practically any desired extent" by X-rays; and that "rearrangements in the order of the genes may be produced in abundance by X-rays."

It is seen from these reports that radium emanation and X-ray irradiation caused marked changes in the living organisms, affecting both the soma and the germ-plasm.

ORIGIN OF THE STOCK USED

The animals used in this experiment are the descendants of mice X-rayed by Little and Bagg, and which were reported by them in their communications of 1923 and 1924. These mice were selected from a stock of colored animals which had been inbred for several years by Miss A. E. C. Lathrop and her successor, Mrs. Gray. The latter has stated that at no time have eye or foot abnormalities of the type described in this paper, or of any similar type, appeared in this stock.

CONDITIONS OF EXPOSURE TO X-RAYS

In the original experiment of Little and Bagg, animals of both sexes were separated into random groups, one group being X-rayed and the other being held as controls. The X-rayed animals (all of which were adults when irradiated), twenty males and ten females, were treated in the following manner:

The physical conditions were —

1. Target skin distance, 12 inches.
2. Spark gap, two and one half inches.
3. Ten milliamperes of current.
4. No filter.
5. Twelve-second exposures were given upon five successive days.

6. The mice were confined in a small space directly beneath the X-ray tube. The entire dorsal surface of the body was exposed.

Except for a ten-week period of sterility, no immediate physiological effects were observed to follow the treatment.

Of the 20 males, 14 died or were sterile and gave no young. Of the 10 females, 3 died without leaving descendants, 3 were mated with 3 different males, and the other 4 were divided into 2 groups of 2 with a treated male for each group. Two treated males were mated with untreated females. Of these matings, female 85, mated to male 49 (both treated animals), gave 3 normal young. These were bred *inter se* and gave 6 young which were themselves inbred brother to sister. Among the offspring, a single mouse (♂1369) was observed to have an abnormal eye. After the appearance of this abnormal male, 16 abnormal young were obtained from this generation.

The same abnormalities were found in the third generation of a different pair (♀86 × ♂36) of X-rayed individuals.

No abnormalities occurred in over 2,000 control animals.[2]

Pedigree Charts I, II, and III (Figs. 41–43) show the lines of descent of many of the stock animals. The numbers to the left of the vertical lines are the ledger numbers of the females involved in the crosses; the numbers to the right of the vertical lines are the ledger numbers of the males to which they were bred. Underneath the ledger numbers are written the descriptions of the abnormalities of the animal bearing the ledger number above it. To the right of the ledger numbers of each mating is written a fraction, the numerator of which represents the number of abnormal young produced by this pair, while the denominator represents the total number of young born to this mating. The following symbols are used to describe the deformities of the abnormal animals:

1. *hh* for the head or eye abnormality.
2. *ff* for the foot deformity.
3. *slsl* for the saddled condition of the back.

[2] Since that time several thousand additional animals have been produced by this stock. All are normal.

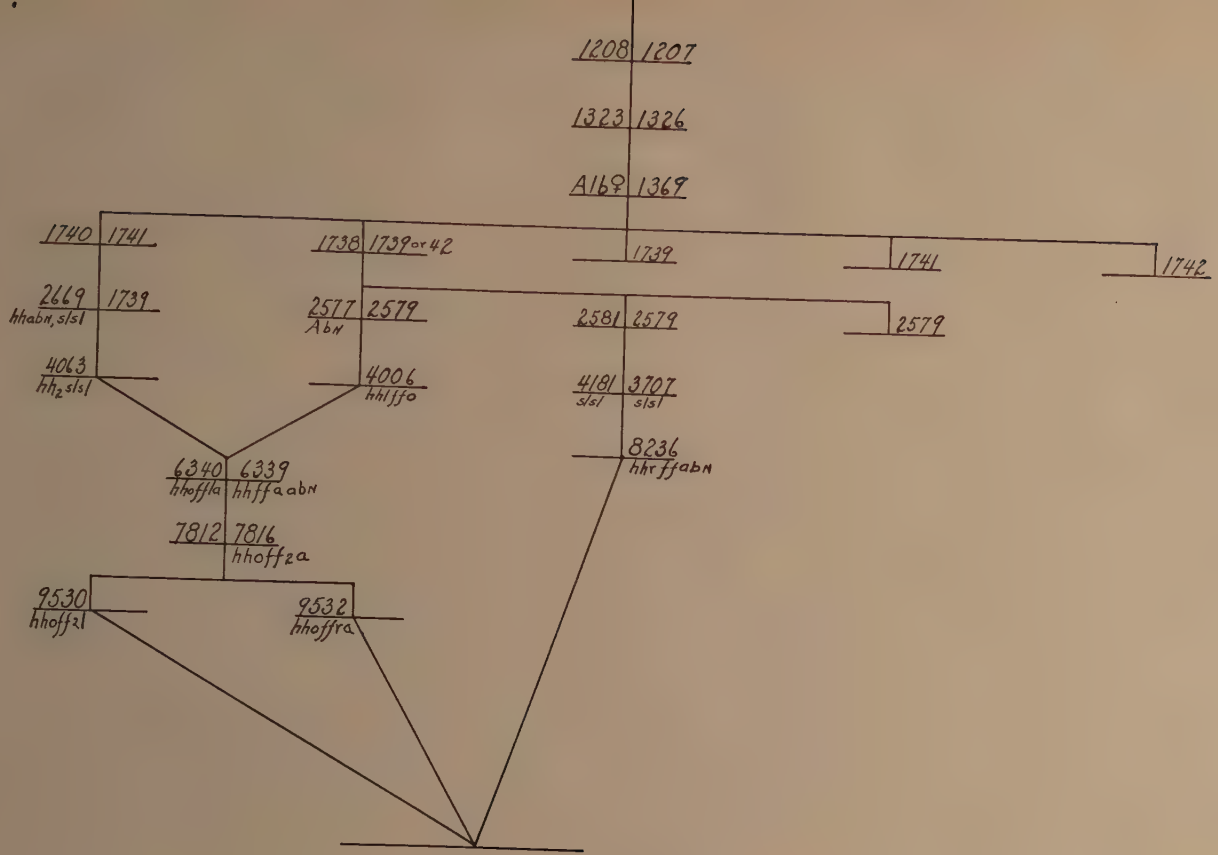

FIG. 41. Pedigree chart I

In this manner, *hhrffralp* is used to designate an animal which was abnormal in its right eye as well as in its right anterior and left posterior feet.

Chart I (Fig. 41) shows the lines of descent of the animals used in the present experiment. Starting with the mating ♀85 × ♂49, the animals were inbred for two generations, producing as an F_3 animal abnormal male 1369. This male, outcrossed to a normal albino female of the Bagg strain, produced 5 young — 2 females and 3 males, all of which were normal. F_1 female 1740 of this litter mated to her brother 1741 gave, among others, female 2669, which was abnormal-eyed. Mated to the sibling of her parents (♂1739) she produced female 4063 *hh*$_2$*slsl*. The second female (♀1738) of the original outcross mating (alb. ♀ × ♂1369) bred to her brother (either ♂1739 or ♂1742) produced 2 females and 1 male. The first of these females (♀2577), mated to her brother (♂2579), gave male 4006, which had an abnormal left eye. This male (♂4006) mated to female (♀4063) mentioned above, gave 2 abnormal young — female 6340 which was abnormal in its left foreleg, and male 6339 which also had an abnormal front leg. These two animals (♀6340 *hhoffla* × ♂6339 *hhoffabn*) gave female 7812, which was somatically normal, and male 7816, which was abnormal in both front feet. These two animals when mated (♀7812 *hhoffo* × ♂7816 *hhoff*$_2$*a*)[3] gave two females — female 9530 *hhoff*$_2$*l* and female 9532 *hhoffra*.

Another daughter of the mating (♀1738 × ♂1739 or ♂1742) namely, female 2581, mated to her brother 2579, produced in different litters female 4181 and male 3707. Both these animals were saddled. Mated to each other, they produced male 8236 which had an abnormal foot. This male, bred to the two sisters (♀9530 *hhofflalp* and ♀9532 *hhoffra*) mentioned above, was the starting point of the stocks from which the data of the present computations were compiled.

Turning to Pedigree Charts II and III (Figs. 42–43), we are able to trace the lines of descent of the young of male 1369 and the normal Bagg female through fifteen generations. For the most part, this descent has been through brother to sister mating

[3] In certain of the earlier records *ff*$_2$*a* is used interchangeably with *fflara*.

(in a number of cases, females have been bred to their father, and in some instances a male has been used which was not as closely related as a brother). All the animals used, however, were the descendants of male 1369 through the cross to the normal Bagg females.

DESCRIPTION OF THE FOOT ABNORMALITIES

Figures 44–46 show drawings of adult mice of the stock first described by Little and Bagg (1923, 1924). These deformities originally appeared in a colored race of mice, but have since been extracted and are now carried by albinos.

Figure 44 shows a left eye which is only slightly abnormal, the deformity being apparent only in the enlarged pigmentation[4] of the lids. The left front foot indicates one of the more extreme types of deformity. All the bones are reduced, the metacarpals and phalanges being much shortened. The left hind foot demonstrates much the same type of deformity, the remnants of the long bones of the foot being flexed dorsally in a marked degree. The drawing exaggerates to some extent the deformity of the leg, but there was a marked atrophy in the region proximal to the ankle joint.

Figure 45 shows another mouse of this same stock. The right eye of this animal is more markedly abnormal than the left eye of the mouse shown in Figure 44. The right front foot in this case demonstrates the slight shortening of the bones which sometimes occurs. The bones of the right hind foot are seen to be grossly abnormal. This mouse also demonstrates the deformity of the head which sometimes accompanies this eye defect. When compared with the head of the mouse in Figure 44, it is seen to be longer and the frontal portion much flatter.

Figure 46 shows a still greater atrophy of the right eye, and a shortening of the bones of the right anterior foot. Here, as in Figure 45, the foot is apparently not distorted by twisting.

[4] It is interesting to note that, although the animals are albinos, in some cases of abnormality, pigment, possibly pathological in nature, may be formed at or near the eye.

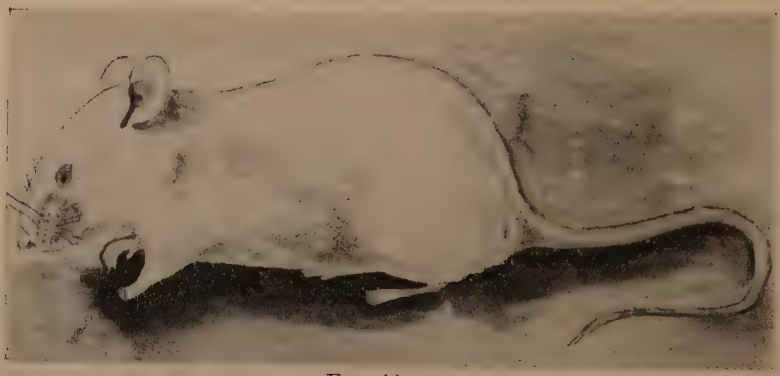

FIG. 44

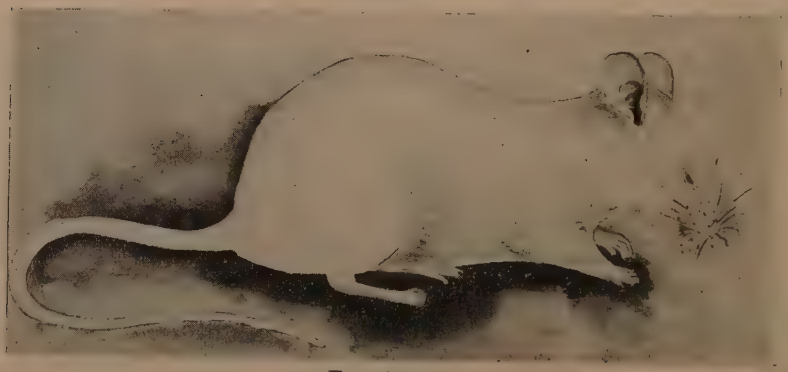

FIG. 45

FIG. 46

FIGS. 44–46. Drawings showing variations in the abnormalities of the eyes and the feet

THE NORMAL FOREFOOT

In the normal anterior foot (Figs. 47_1 and 49_1) there are seen to be eight bones in the carpus, five metacarpals, five first phalanges, four second phalanges, and five third phalanges. The thumb or first digit is seen to be very short, the second phalanx is absent, and the distal phalanx extends but a short distance beyond the middle of the metacarpal bone of the index digit. On the thumb there is no nail or claw. The index digit is much

FIG. 47. Drawings comparing abnormal with normal feet

longer than the thumb, the distal phalanx extending well beyond the middle of the proximal phalanx of the second or middle finger. The musculature between the index and second digits extends well down until it is proximal to the metacarpal phalangeal joint of the second finger. The second and third digits are of approximately the same length, the musculature between them extending to a point just proximal to the metacarpal phalangeal articulation. The fourth or little finger is the shortest of all the digits save the thumb, extending about half-way up the proximal

phalanx of the third finger. All four digits bear nails or claws and when in the relaxed state are approximately straight, the bones all lying in the same plane horizontally.

ABNORMALITIES OF THE FOREFOOT

The abnormalities of the front foot vary through a wide range of distortion, extending from slight twists in a single component of one of the digits to a fusion of all the bones and tortions in all directions.

FIG. 48. Types of abnormal feet

Figure 47_3, which is a drawing of the right anterior foot of mouse 1609, shows the thumb to be in approximately the correct position, but smaller than the normal thumb. The four fingers are seen to be very short, the middle digits being twisted toward the thumb. The musculature extends very nearly to the end of the distal phalanges. The little finger, instead of being set at an angle to the third digit, is drawn in very close to it; the musculature and skin which join the two extend clear to the nail on the proximal side. All four of the nails are more or less

contorted and twisted, that of the little finger being the most disfigured.

Figure 47_4, the left anterior foot of mouse 1515, is of approximately the same type as the foot shown in Figure 44, the middle fingers being apparently fused. Figures 47_5 (right anterior foot of mouse 1617), 47_6 (right anterior foot of mouse 1308), 47_7 (left anterior foot of mouse 1617), 47_8 (left anterior foot of mouse 1235), 47_9 (right anterior foot of mouse 1507), 47_{10} (left anterior foot of mouse 1507); 48_1 (right anterior foot of mouse 1718), and 48_2 (left anterior foot of mouse 1514) all show this same general type of abnormality. Figure $48_{1,2}$ shows, in addition to the lateral and medial tortions, a dorsal bending as though pulled by the extensor muscles.

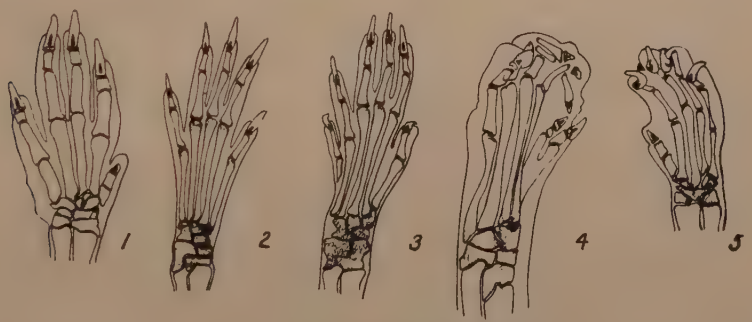

Fig. 49. Variations in bony structure

More deformities of the extremities are shown in Figure 48_{2-11}. In Figure 48_3 (left anterior foot of mouse 1618) the thumb has almost entirely disappeared, while the index and second digits are bent sharply toward the middle line. The third and fourth digits are of nearly the same length and diverge markedly from each other. In Figure 48_4 (left anterior foot of mouse 1684) the palmar pad extends in a proximal direction well beyond the base of the thumb, and the four fingers extend radially from a common center. All four fingers show a slight dorsal flection. Figure 48_5 (left anterior foot of mouse 1340) shows a marked atrophy of all the bony elements of the foot, fusions of all the digits and a sharp flection. Figure 48_6 (left anterior foot

of mouse 1513) shows even greater atrophy than does Figure 48_2. Here also the dorsal flection is very sharp. Figure 48_7 (right anterior foot of mouse 1513) is of the same general type as those first described except that the dorsal flection is most extreme, the bones being bent dorsally so sharply that the nails appear to grow from the back of the foot. Figure 48_8 (right anterior foot of mouse 1507) shows a case of polydactylism.

THE NORMAL HIND FOOT

In the normal hind foot (Figs. 47_2 and 49_2) there are seven bones in the tarsus, five metatarsals — the middle three of approximately the same length and the two outside bones extending well beyond the middle of the metatarsals of the first and third toes. The middle phalanx is missing from the great toe, but is present in all of the digits. The three middle digits are of about the same length; the musculature between them extends almost to the region of metatarsal phalangeal articulation. The great toe and the little toe are set at acute angles to the other toes, the musculature extending to the metatarsal phalangeal joint in each instance.

ABNORMALITIES OF THE HIND FOOT

Abnormalities of the hind foot vary over a wide range, as do those of the front foot. Figure $48_{9,\ 10,\ 11}$ reveals three extreme variations. Figure $48_{9,\ 11}$ (left posterior foot of mouse 1339 and right posterior foot of mouse 1381) has very similar types, showing as they do marked atrophy of all the bones and great lateral and dorsal tortions. In Figure 48_{10} (left posterior foot of mouse 1240) the bones of the foot are so completely absent that the leg appears to end in the tarsal bones.

SEGREGATIONS OF NORMAL STRAINS OR STRAINS WITH LOW PERCENTAGE OF ABNORMALITY

Pedigree Chart IV (Fig. 50) shows the descendants of mating ♀ 10913 *hh*$_2$ *ffrp* × ♂ 10916 *hhofflp*, 21 per cent of which were abnormal. Five of the daughters of this mating were bred and all gave abnormal young. All but one mating of these young (♀20439 *hhlffla* × ♂ 20437 *hhlffo* — 14 per cent abnormal young)

gave ratios of abnormals to normals which were higher than the ratio of the parent mating. Mating ♀20441 *hhlffo* × ♂20437 *hhlffo* gave 67 per cent abnormals, and two of their young gave 87 per cent abnormal young. Another daughter (♀20626) of this mating (10913 × ♂10916) bred to a distantly related male (♂20678) gave 40 per cent abnormal young. Three of their daughters mated to their brother gave 50, 66, and 20 per cent abnormal young. A fourth daughter of the mating ♀10913 × ♂10916, female 20627 *hh*$_2$ *fflp*, mated to male 20678 *hhrffra*, produced 55 per cent abnormal young.

One of these females (♀20799 *hhoffo*) mated to her brother, (♂20798 *hhlffo*), had six daughters which were mated to their siblings. Two of these (♀21032 *hhrffo* and ♀21034 *hhrffo*), mated to their brother (♂21038 *hhofflp*), gave all normal young. However, two of the normal-appearing daughters of the pair ♀21034 × ♂21038, when mated to their brother, gave 57 per cent abnormals in one instance (♀21536 *hhlffo* × ♂21537 *hhrffo*) and 100 per cent abnormals in the second (♀21538 *hhrffo* × ♂21537 *hhrffo*).

Another daughter of the mating ♀20799 × ♂20798, female 21991 *hhrffra*, mated to her brother 21993 *hhrffo*, produced 50 per cent abnormals. Two of these animals (♀22174 *hhoffo* × ♂22175 *hhlffra*) produced young, all of which were normal. In all, there have been 104 descendants of this pair (♀22174 × ♂22175), yet only two abnormal-footed individuals have appeared among them.

This pedigree shows that it is possible to segregate strains in this particular abnormal-footed race which will continue to produce a large percentage of abnormal young. It also shows in the case of descendants of female 21991 and male 21993 that strains may also be segregated which will show little or none of the foot abnormalities. However, normality in appearance of the young of any individual pair which are themselves the young of abnormal-producing parents, is not a criterion of genetic normality, as is shown by the young of mating ♀21034 × ♂21038.

If this same thing is represented graphically in Graph I (Fig. 51) where the percentage of abnormal young is represented along the ordinate and the various succeeding generations along the

abscissa, it is found that the young of this high abnormal line fluctuate between 0 and 100 per cent abnormals.

Here is seen the apparent tendency toward separation into normal and abnormal lines. Mating ♀20799 × ♂20798 produced

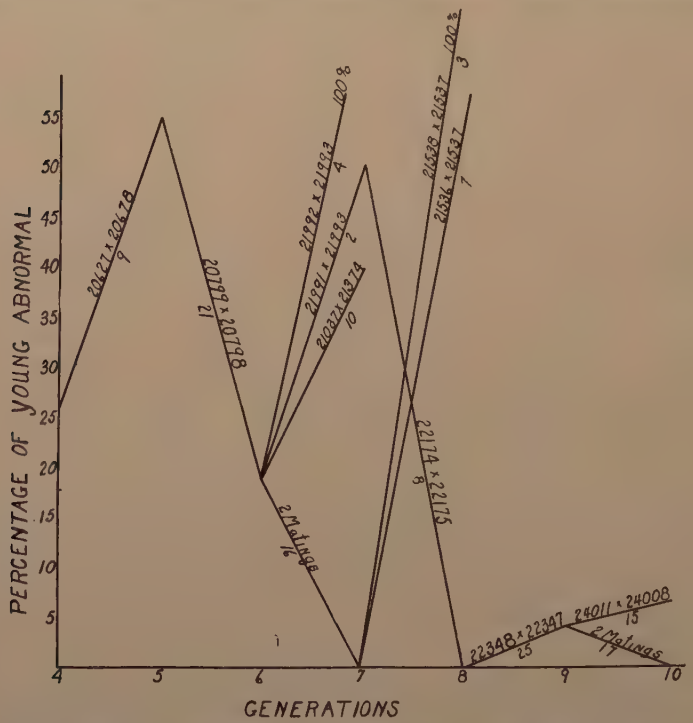

FIG. 51 (Graph I). Percentage of abnormality in succeeding generations

EXPLANATION OF FIGURES 51–55 (GRAPHS I–V)

In this and the following graphs, the numbers above the lines are the ledger numbers of the individuals involved in the matings. Below the line is the number of young which each mating produced.

five females. Two of these when bred produced young which were all apparently normal. Three other females from this same mating, when mated to their brothers, produced abnormal young in excess of the ratio of the parent mating. The young of one of these matings (♀21991 × ♂21993) when bred *inter se* (♀22174 ×

♂22175) produced young all of which were apparently normal. It is of interest to note that in both of the cases where this line tended toward normal, the normal-appearing animals produced abnormal young, in one case to the extent of 100 per cent (♀21538 × ♂21537).

When Pedigree Chart II (Fig. 42) is shown in the same way

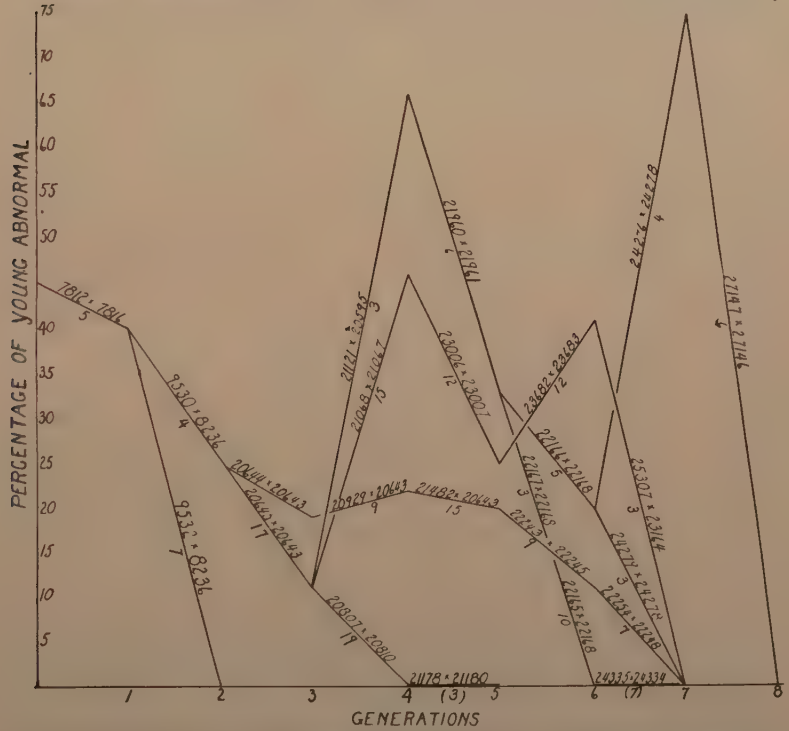

FIG. 52 (Graph II.) Percentage of abnormality in succeeding generations

(Graph II, Fig. 52), it is found that in the first seven generations three different lines segregate, all of which have a tendency toward normality. The first of these reaches normality in two generations, the second in four, and the third in seven generations. Other lines, after fluctuating three, four, or five generations between twelve and seventy-five per cent abnormals, all segregate and show a tendency toward normality.

Having reached normality in external appearance, these individuals may or may not breed true to normal; some of them reach as high as forty per cent abnormal young in two generations from normality.

In Graph III (Fig. 53) the same line of mice returns to normality three times; and in as many instances, these normal-appearing individuals gave birth to abnormal young. This same type of behavior is shown in Graph IV (Fig. 54), which is computed from Pedigree Chart II.

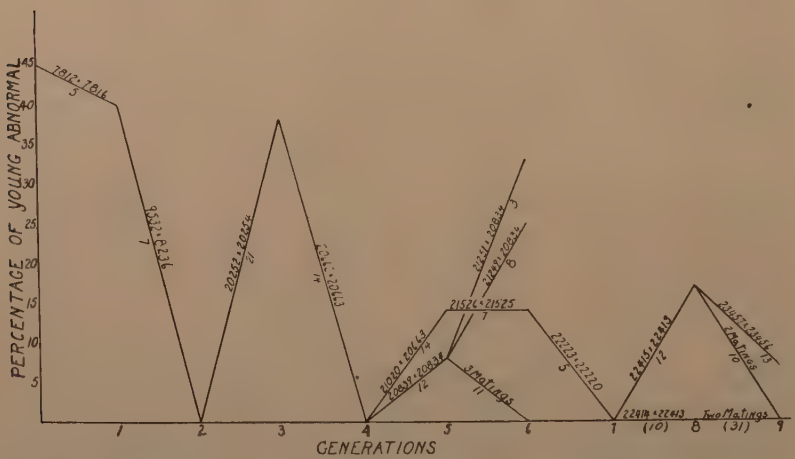

FIG. 53 (Graph III). Percentage of abnormality in succeeding generations

From these charts and graphs it is seen that inheritance of the abnormal foot defect is very irregular; that highly abnormal lines may breed true to high abnormality or may throw young all of which are normal; and that low abnormal lines may throw young which when bred will give birth to as high as 100 per cent abnormals. It will, therefore, be of interest to note the general trend of the percentage of abnormal young born in the different generations in this stock.

The mice recorded upon Pedigree Charts I, II, and III (Figs. 41–43), range from the fourth generation after the abnormality first appeared in the stock (♂1369) to the fourteenth generation. In computing the percentage of abnormal mice in each genera-

tion (Graph V, Fig. 55), it is found that the percentage of abnormal young in the fourth generation was 33, in the fifth generation 47, in the sixth 28, in the seventh 21, in the eighth 17, in the ninth 12, in the tenth 11, in the eleventh 18, in the twelfth 9.5, in the thirteenth 13, and in the fourteenth 20.

From this curve, it is seen that the percentage of abnormality has a tendency to grow less from the sixth to the thirteenth generations. The probability is that the sharp rise of the curve at

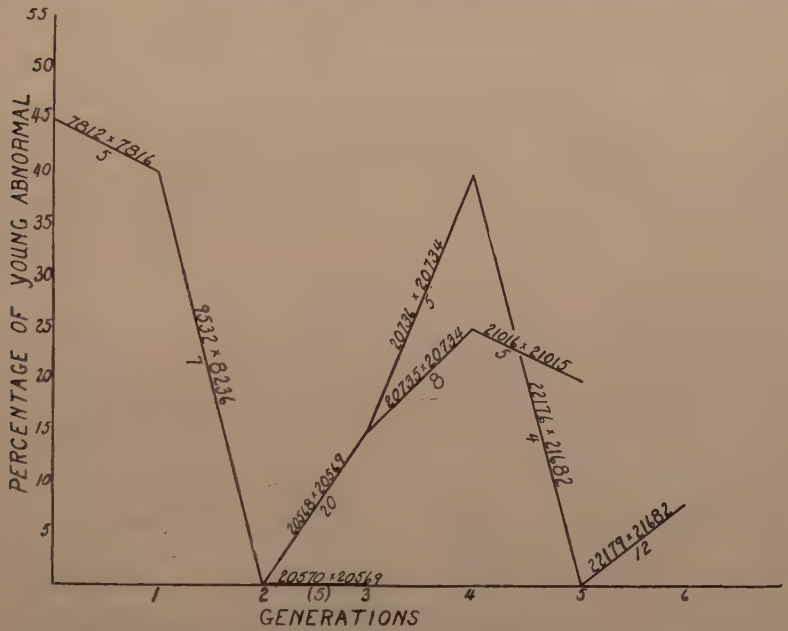

Fig. 54 (Graph IV). Percentage of abnormality in succeeding generations

the fourteenth generation is due to the smallness of the numbers involved and to the fact that the strain which has reached this generation happened to be matings which were showing a momentary high percentage of abnormality.

From this last graph (Graph V, Fig. 55), it is also seen that, while the percentage of abnormal young apparently decreases between the fourth and the ninth generations, it tends to remain at a constant level. A drop in percentage, therefore, in any given

line, does not necessarily mean that the abnormality is fading out genetically.

THE PROOF OF INHERITANCE

In Pedigree Chart I (Fig. 41) is shown male 1369, which was the first abnormal animal recorded by Little and Bagg in their original paper. This male (♂1369), mated to his sister (♀1367), gave 31 young, 3 of which had abnormal feet, showing in this way that either one or both of them carried the character or characters which cause the abnormality. That male 1369 carried the

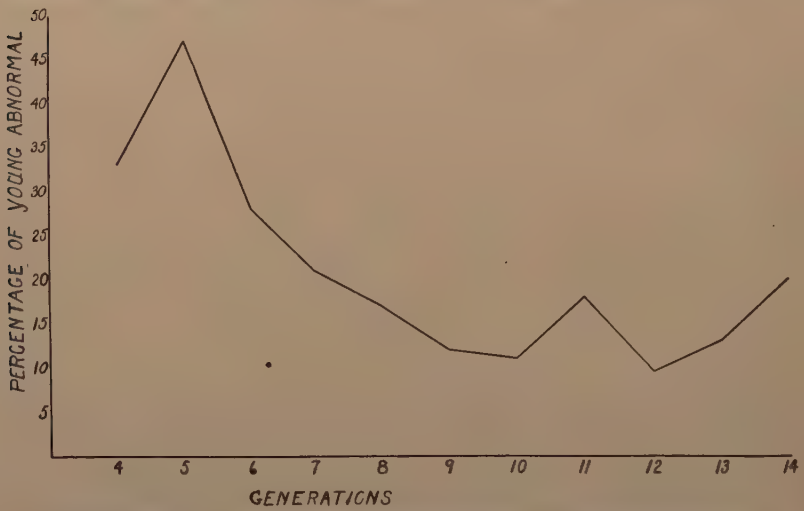

FIG. 55 (Graph V). Percentage of abnormality in succeeding generations

gene or genes for this deformity is shown by the fact that abnormal feet were found in his inbred descendants after he had been out-crossed to a normal female (Little and Bagg, 1923, 1924).

Pedigree Chart I (Fig. 41) shows the record of this out-cross. Female 1740, when mated to her brother (♂1741), gave female 4063 *hh*$_2$*slsl*, which was the mother of the first abnormal-footed animal that appeared in this line after the out-cross.

The descent of the father of this abnormal animal is shown on the same Chart. Female 1738, mated to her brother (either ♂1739 or ♂1742), gave female 2577, which was abnormal, and

male 2579, which was normal in appearance. These two animals (♀2577 and ♂2579) had a son (♂4006 *hhlffo*), which when mated to female 4063, before mentioned, gave female 6340 *hhoffla* and male 6339 *hhoffabn*. After the first appearance of the abnormality following the out-cross, it appears regularly in the descendants of these mice. (See Pedigree Charts II and III, Figs. 42–43.)

TYPES OF INHERITANCE

That this abnormality behaves genetically as hypostatic to normal is demonstrated by Pedigree Chart I (Fig. 41). This conclusion becomes much more convincing, however, if the F_1 generation of an out-cross made in this laboratory is taken into consideration. In this experiment three brothers (♂24208 *hh₂ffrala*, ♂24209 *hh₂ffrala*, and ♂24210 *hhlffrala*) were out-crossed to normal unrelated albino females of the Bagg strain.

RECORD OF OUT-CROSS

Mating	No. of Young	No. of Litters	Mating	No. of Young	No. of Litters
36 × 24208	1	4	Brought forward	31	181
57 × 24208	2	8	58535 × 24210	1	5
58+1 × 24210	1	4	58726 × 24210	2	14
59 × 24210	1	5	58758 × 24210	2	11
69 × 24208	1	6	58759 × 24210	1	7
71 × 24208	1	9	58761 × 24210	2	11
72 × 24208	3	20	58787 × 24210	2	13
73+1 × 24208	2	14	58788 × 24210	3	20
74 × 24208	2	15	58858 × 24209	1	10
75 × 24208	4	27	58879 × 24209	2	13
76 × 24208	1	5	58880 × 24209	2	14
77 × 24208	3	13	58881 × 24209	2	12
97 × 24208	2	12	58882 × 24209	2	14
99 × 24208	1	6	58919 × 24209	2	13
58439 × 24210	2	10	58920 × 24209	3	19
58498 × 24210	2	10	58924 × 24209	3	14
58532 × 24210	2	13	58925 × 24209	2	12
			58926 × 24209	3	18
	31	181	Total	66	401

Average litter size, 6.07.

From these matings, 66 litters were obtained in which there were 401 young, an average of 6.07 young per litter. All the offspring of these matings were normal in appearance.

NORMAL OVERLAPS IN RELATION TO OTHER KNOWN MORPHOLOGICAL VARIATIONS

Morphological abnormalities in mammals are by no means rare, since many different forms have been reported. In mice one of the best known of the deformities which occur is the defect described as "waltzing." This is a condition affecting the middle ear, making the afflicted individuals progressively deaf, and also influencing the semicircular canals in such a way that the animals lose their sense of balance and keep up a continual whirling motion. This condition has been described by Yerkes (1907), who found the character to behave as a recessive to normal and demonstrated that the F_2 waltzers show a marked extension of variability in the amount to which the character manifests itself.

A second morphological character which appears in mice is that of hairlessness and roughness of the skin. This condition has been described by Allen (1904), who found it to be a recessive. Brooke (1926) has also described this character.

A third deformity appearing in mice is that of kinky tail, described by Plate (1909), and later by Blank (1916), who discovered that the natural form of growth was distorted by inequalities in growth of the epiphyses of the caudal vertebrae. This character is inherited irregularly, two abnormals sometimes giving normal young; and normal animals extracted from such crosses sometimes give kinky-tailed individuals.

Danforth (1925) has reported a "strain of doubles" in mice: "The anomalous individuals range from 'Y' shaped specimens with four hind legs and two tails to those with relatively slight degree of doubling in the external genitalia . . . apparently connected with the same manifestation is the appearance of hemorrhagic testes, *spina bifida*, and occasional other anomalies such as microphthalmia."

Bonhote (1912) has reported the waltzing character in *Rattus rattus*. The inheritance of this character has, however, never been worked out, but it appears to be recessive and sex-linked.

In guinea pigs, Castle (1906) has described a polydactylous

race which behaves irregularly. Although it is supposedly a dominant, individuals homozygous for this character sometimes throw normal-appearing young, which in turn may have polydactylous progeny.

Wright (1916) has reported that rough coat in guinea pigs varies over a wide range in its manifestations, being influenced by modifying factors to such an extent that smooth-coated individuals derived from this stock sometimes throw rough-coated young.

As mentioned before (see page 510), variability of morphological characters brought about in mammals by external agents has been reported by Stockard and Papanicolaou, by Guyer and Smith in rabbits, and by Little and Bagg in mice. All these investigators have described eye defects accompanied by variations of physical instability, ranging from normal to such grossly abnormal defects that the animals could not survive.

In the present experiment, great variation in the amount of abnormal feet has been shown (Figs. 44–49). These abnormalities range from normal-appearing feet to almost complete absence of the extremity.

That many of the normal-appearing individuals of this strain are normal overlaps is illustrated by the following:

1. Miss A. M. Bean,[5] while working upon the skeletal structure of the extremities of individuals in this stock, found that: (*a*) These abnormalities grade from slight degrees of departure from the normal types to grossly malformed members; (*b*) A reduction of the tarsal and carpal bones by fusion occurs in practically all the abnormal feet and in some of those otherwise apparently normal.

2. In Table I is shown the record of 106 matings of normal-appearing individuals homozygous for abnormal feet. Forty-nine of these threw abnormal young, and the young of the remaining 57 matings were normal. This shows that at least 46 per cent of the normal-appearing animals in that strain are genetically abnormal, although physically they overlap the normal condition.

[5] Paper in press.

INADEQUACY OF EXPLANATION OF THE GENETIC BEHAVIOR ON THE BASIS OF A SINGLE GENE

While the Pedigree Charts and the record of the out-cross matings (see page 529) prove conclusively that this deformity is definitely inherited in a hypostatic manner, the data do not show any of the simple ratios which might be expected if it were the manifestation of the action of a change from normality in a single gene.

This fact is demonstrated by the results of the back-cross matings of these same three abnormal males (♂24208, ♂24209, ♂24210) to their daughters by the normal Bagg females (Table II).

If the expectations are computed for such a cross upon the supposition that the abnormality is a simple Mendelian recessive to a normal dominant, it might be expected that the out-cross

TABLE I

SHOWING THE DISTRIBUTION OF THREE CLASSES OF MATINGS IN THE STOCK MICE

CLASS	Number of matings	Matings which threw abnormals	Number of litters	Number of young	Average litter size	Matings which threw normals	Number of litters	Number of young	Average litter size	TOTAL YOUNG	TOTAL LITTERS	AVERAGE LITTER SIZE
ffo × ffo	106	49	107	575	5.37	57	88	407	4.61	982	195	5.03
ffo × ffabn	68	55	95	496	5.22	13	17	86	5.05	582	112	5.19
ffabn × ffabn	42	35	67	318	4.73	7	9	40	4.44	358	76	4.69
TOTAL	216	139	269	1389	5.16	77	114	533	4.65	1922	383	5.01

TABLE II

SHOWING THE DISTRIBUTION OF THE BACK-CROSS MATINGS

CLASS	Number of matings	Matings which threw abnormals	Number of litters	Number of young	Average litter size	Matings which threw normals	Number of litters	Number of young	Average litter size	TOTAL YOUNG	TOTAL LITTERS	AVERAGE LITTER SIZE
ffo × ffabn	71	51	79	579	7.3	20	25	150	6.0	729	104	7.00

represented by the formula $FF \times ff$ would produce one type of young, all of which would have the genetic constitution *Ff*. These animals would all be normal in appearance inasmuch as the normal gene is dominant over the gene for abnormality. This much of the expectation is borne out by fact. (See record of matings, p. 529.)

If, however, these F_1 females of the formula *Ff* are back-crossed to their fathers, whose genetic formulae are all *ff*, it might be expected that the resulting young would be of the formulae *Ff* and *ff* in equal numbers, since the mothers form two types of gametes and the fathers but one. The experimental data do not even approximate a one to one ratio.

In this cross, 71 different matings were recorded (Table II). These produced 104 litters in which were 729 young. If the deformity is dependent upon a single Mendelian factor, it should be expected from these computations that 364 of these young would have abnormal feet. In reality there were 124 abnormal individuals (Table V). This is but 17 per cent or one third of the number expected in a back-cross involving a simple recessive.

The deficiency may be attributed to one or both of two causes:
1. Many of the normal-appearing individuals may be genetically

abnormal overlaps with the normal type; 2. The homozygous individuals may be lethal.

The data compiled for the stock mice indicate that part of the deficiency in the number of observed abnormal animals may be explained by the first of these causes. Table I shows that in 106 matings of apparently normal individuals, 49 threw abnormal young, and 57 threw normals only. This would indicate that at least 46 per cent of the somatically normal-appearing animals in this stock are genetically abnormal.

Since it is impossible to obtain a pure breeding strain of these abnormalities, it may be that the homozygous recessives are lethal. If this is true, the average litter size of the back-cross matings should be larger than that of the stock matings, or of those matings following the back-cross in which it is possible to obtain that combination of genes which will produce homozygous recessive individuals.

The stock mice in this experiment produced 1922 young in 383 litters with an average litter size of 5.01. In the F_1 generation there were 66 litters in which there were 401 young, an average of 6.07 per litter. In the back-cross generation there were 729 young produced in 104 litters, with an average of 7.00 per litter. The F_2 generation, or the stock mice after the back-cross, produced 318 young in 61 litters with an average of 5.2 per litter. In the normal stock of Bagg albinos, from which the females for the out-cross were obtained, the average litter size is found to be 5.2 (1067 young in 205 litters).

It will be seen from these figures that the stock mice, the F_2 generation, and the normal Bagg stock are very similar in regard to litter size. By computing the expectation of the effect of a lethal factor in the back-cross generation upon the basis of the average litter sizes in the stock and out-cross mice, it is estimated that the back-cross should be larger than that of the stock and smaller than that of F_1. Since the observed average litter size in the back-cross generation is 7.00, and that of F_1 is 6.07, it appears that the data do not provide supporting evidence that some of the stock abnormals are lethal, but rather that the larger litters in the out-cross and back-cross generations

are due to the vigor of heterosis. The data are, however, not to be considered as completely conclusive against the presence of some lethal influences.[6]

IF BOTH PARENTS ARE ABNORMAL, THE PROBABILITY OF ABNORMAL YOUNG IS INCREASED

The mice available for the compilation of data in this experiment may be divided into four classes:

1. Those matings of the stock mice following the out-cross of male 1369 to normal Bagg albinos (stock).
2. The out-cross of the three abnormal brothers (♂24208, ♂24209, ♂24210) to the normal females.
3. The back-cross of these same males to their daughters.
4. The back-cross F_2 following this out-cross.

In the following discussion the first of these classes will be designated "stock mice," the second "out-cross," the third "back-cross," and the fourth "back-cross F_2."

By turning to Table III, it is found that in the stock mice there were 57 *ffo* × *ffo* matings which threw all normal young, and 49 which threw abnormals. In the back-cross F_2 stock there were 8 matings which threw only normals and 4 which threw abnormals. In the stock mice there were 13 matings of the type *ffo* × *ffabn* which threw normals and 55 which gave abnormals as compared with 20 and 51 in the back-cross stock, and 3 and 12 in the back-cross F_2 stock for matings of this type. In the matings of the type *ffabn* × *ffabn*, the stock mice produced 7 matings which threw normal young and 35 matings which threw abnormal young as compared with 1 and 17 in the back-cross F_2 matings of this type. In totaling these results, it is found that in the *ffo* × *ffo* matings, 65 produced all normal young and 53 gave some abnormals. In the *ffo* × *ffabn* type of mating, 36 produced all normal young and 118 gave some abnormals. In the *ffabn* × *ffabn* type of mating, 8 threw all normal young and 52 produced some abnormals.

[6] Intra-uterine foetal counts are being made in this stock. The data to date show that there is an average of 1.4 degenerating embryos in each mouse. The average litter size of the mice examined would have been 6.5.

TABLE III

SHOWING RATIOS OF MATINGS WHICH THREW ABNORMALS

TYPE OF MATING	A Number of matings which threw normals	B Number of matings which threw abnormals	Ratio of A to B
Stock ffo × ffo	57	49	1 : 0.86
Back-cross F_2 ffo × ffo	8	4	1 : 0.50
Total ffo × ffo	65	53	1 : 0.81
Stock ffo × ffabn	13	55	1 : 4.23
Back-cross ffo × ffabn	20	51	1 : 2.55
Back-cross F_2 ffo × ffabn	3	12	1 : 4.00
Total ffo × ffabn	36	118	1 : 3.28
Stock ffabn × ffabn	7	35	1 : 5.00
Back-cross F_2 ffabn × ffabn	1	17	1 : 17.00
Total ffabn × ffabn	8	52	1 : 6.50

From these data it is apparent that, when two normal-appearing animals of this stock are bred, the chance is about one to one that some of the young will have abnormal feet. If an abnormal-footed individual is bred to a normal-appearing animal of this stock, the chances of producing abnormal animals from the mating are three to one. If two abnormal-footed individuals are bred, the chances increase to six to one that the mating will produce some abnormals.

If Table IV is examined, it will be seen that 575 young were born to the 49 matings which produced abnormal young. Of these, 110 or 19.1 per cent were abnormal-footed. In the back-cross F_2 matings of this same type, 42 were born to four matings, seven, or 16.6 per cent, of the individuals were abnormal-footed. If the percentage of abnormal individuals born to animals producing abnormals in the *ffo* × *ffabn* type of mating is computed, it is found to be 28.4 per cent in the stock mice, 21.4 per cent in the back-cross, and in the back-cross F_2 38.0 per cent. In the matings of the *ffabn* × *ffabn*, this percentage increases to

TABLE IV

SHOWING PERCENTAGE OF ABNORMAL YOUNG IN ABNORMAL MATINGS

TYPE OF MATING	Matings — young all normal	Matings — some abnormal young	Abnormal individuals	Young born normal matings	Young born abnormal matings	Percentage of abnormal young abnormal matings
Stock ffo × ffo	57	49	110	407	575	19.1
Back-cross F_2 ffo × ffo	8	4	7	89	42	16.6
Total ffo × ffo	65	53	117	496	617	18.9
Stock ffo × ffabn	13	55	141	86	496	28.4
Back-cross ffo × ffabn	20	51	124	150	579	21.4
Back-cross F_2 ffo × ffabn	3	12	35	14	92	38.0
Total ffo × ffabn	36	118	300	250	1167	25.7
Stock ffabn × ffabn	7	35	105	40	318	33.0
Back-cross F_2 ffabn × ffabn	1	17	43	4	77	55.8
Total ffabn × ffabn	8	52	148	44	395	37.4

33.0 in the stock mice, and to 55 in the back-cross F_2 stock. In totaling the matings of these three types in the different stocks, it is found that in the *ffo* × *ffo* type matings which produce abnormal young, 18.9 per cent of the young are abnormal. In the *ffo* × *ffabn* type this percentage increases to 25.7 and in the *ffabn* × *ffabn* type to 37.4.

Table V shows in the column to the left the number of young born in the three types of matings in the several stocks. To the right of this column is recorded the number of these young which were abnormal-footed. Reading the totals of the three types of matings, one finds that in this stock, when two normal-appearing animals are bred, 10.5 per cent of the young born are abnormal-footed. When an abnormal animal is bred to a normal-appearing individual of this strain, this percentage increases to 21.1; and when two abnormal animals are mated, 33.7 per cent of the young born are abnormal-footed.

TABLE V

SHOWING PERCENTAGE OF YOUNG WHICH HAD ABNORMAL FEET

TYPE OF MATING	Number of young born	Number of young with abnormal feet	Percentage of young which had abnormal feet
Stock ffo × ffo	982	110	11.2
Back-cross F_2 ffo × ffo	131	7	5.3
Total ffo × ffo	1113	117	10.5
Stock ffo × ffabn	582	141	24.2
Back-cross ffo × ffabn	729	124	17.0
Back-cross F_2 ffo × ffabn	106	35	33.0
Total ffo × ffabn	1417	300	21.1
Stock ffabn × ffabn	358	105	29.3
Back-cross F_2 ffabn × ffabn	81	43	53.0
Total ffabn × ffabn	439	148	33.7

From these data it is clear that the greater the abnormality which enters a cross, the greater is the chance that some of the young will be abnormal.

LOCALIZATION OF THE ABNORMALITIES

If this abnormality of the feet is due to a simple recessive gene, it might be expected that the frequency with which each of the four feet appears abnormal will be approximately one fourth of the total number of abnormal feet. A glance at Table VI, however, will show that this is not true. As this table shows, in the *ffo* × *ffo* matings of the stock mice, 11.9 per cent of the abnormalities were in the right anterior, 23 in the right posterior, 30.9 in the left anterior, and 34.1 in the left posterior feet. This demonstrates that in such crosses the susceptibility of the individual feet to this abnormality is not equal. It shows rather that the left side is practically twice as susceptible as the right in that 65 per cent of the abnormalities were upon the left side as against 35 on the right.

In this same stock, when the cross is of the type *ffo* × *ffabn*,

22.0 per cent of the abnormal young have the deformity in the right anterior, and 19.2 in the right posterior as against 35.5 in the left anterior, and 23.1 in the left posterior feet. Here again the left side predominates over the right in the percentage of abnormalities in the ratio of 58.6 to 41.2.

When the cross was of the *ffabn* × *ffabn* type, 14.6 per cent of the abnormalities were in the right anterior foot, 28.4 in the

TABLE VI

DISTRIBUTION OF THE ABNORMALITIES

STOCK	Right anterior	Left anterior	Right posterior	Left posterior	Total number of abnormal feet	Number of young
ffo × ffo	15	39	29	43	126	982
Percentage	11.9	30.9	23.0	34.1	...	....
ffo × ffabn	39	63	34	41	177	582
Percentage	22.0	35.5	19.2	23.1	...	....
ffabn × ffabn	19	43	37	31	130	358
Percentage	14.6	33.0	28.4	23.8	...	....
TOTAL	73	145	100	115	433	1922
Percentage	16.8	33.4	23.1	26.5	...	....
BACK-CROSS						
ffo × ffabn	44	76	20	32	172	729
Percentage	25.5	44.1	11.6	18.6	...	....
BACK-CROSS F_2						
ffo × ffo	2	5	2	2	11	131
Percentage	18.1	45.2	18.1	18.1	...	....
ffo × ffabn	17	25	3	4	49	106
Percentage	34.6	51.0	6.1	8.1	...	....
ffabn × ffabn	18	26	7	10	61	81
Percentage	29.5	42.6	11.4	16.3	...	....
TOTAL	37	56	12	16	121	318
Percentage	30.5	46.2	9.9	13.2	...	....

right posterior, 33.0 in the left anterior, and 23.8 in the left posterior. Here, as in the crosses mentioned above, the predominance of the left over the right side is apparent, although here it is not so marked, being in the ratio of 43 per cent right to 57 per cent left. In the totals of the abnormalities occurring in the four different feet, it is found that in the stock mice as a whole 16.8 per cent of the abnormalities occur in the right anterior, 23.1 in the right posterior, 33.4 in the left anterior, and 26.5 in the left posterior feet. In the totals for right and left, it is found that 39.9 per cent of the deformities occur upon the right side and 59.9 on the left. In contrast to this, if the totals for the two front feet and the two hind feet are calculated, it is found that they approach very closely to equality, there being 50.2 per cent of the abnormal feet in the anterior extremities and 49.6 in the posterior.

In the back-cross generation (Table VI), all the matings were of the type *ffo* × *ffabn*. Here 25.5 per cent of the abnormalities were in the right anterior, 11.6 in the right posterior, 44.1 in the left anterior, and 18.6 in the left posterior foot. In this cross the left side predominates over the right in the ratio of 62.7 per cent to 37.1 per cent. *Unlike the stock mice, the ratio of anterior abnormalities to posterior abnormalities is 69.6 per cent to 30.2 per cent.*

In the back-cross F_2 generation the number of *ffo* × *ffo* type of mating is small, but shows the dominance of the left anterior foot over all the rest in susceptibility to the abnormality in that it is affected in 45.2 per cent of all cases, while each of the rest is affected in 18.1. In the *ffo* × *ffabn* type of mating in this generation, the right anterior foot was affected in 34.6 per cent of the abnormalities, the right posterior in 6.1, the left anterior in 51.0, and the left posterior in 8.1. Here, as in the back-cross generation, the predominance of the left side over the right is shown by a ratio of 59.1 per cent to 40.7 per cent, and the predominance of the anterior part of the body over the posterior in the ratio of 85.1 per cent to 14.2 per cent.

Much the same thing is found in the *ffabn* × *ffabn* cross in this generation. In this type of mating, the right anterior

foot is affected in 29.5 per cent of the cases of abnormality, the right posterior in 11.4, the left anterior in 42.6, and the left posterior in 16.3. Here the ratio of abnormal left feet to abnormal right is 58.9 per cent to 40.9 per cent, and the rate of anterior to posterior abnormalities is 72.1 per cent to 27.7 per cent.

TABLE VII

PERCENTAGES OF ABNORMALITIES

TYPE OF MATING	Right feet abnormal	Left feet abnormal	Anterior feet abnormal	Posterior feet abnormal
Stock.....	39.9	59.9	50.2	49.6
Back-cross.....	57.1	62.6	69.6	30.1
Back-cross F_2.....	40.4	59.4	76.7	23.1

From the totals of these three stocks (Table VII), it is found that the percentages of deformity remain very constant, 40 for the right and 60 for the left. If, however, the groupings are made for the anterior and posterior feet, it is found that there is a progression from equality in the stock mice to 76.7 per cent anterior to 23.1 per cent posterior abnormality in the back-cross F_2 mice.

INHERITANCE OF EACH FOOT IS NOT THAT OF A SINGLE GENE

Because of the variation between the stock mice and the back-cross and back-cross F_2 generations, it may be reasoned that the three brothers used in the out-cross (all of which carried two abnormal forefeet) introduced something into the out-cross in higher concentration than it occurred in the stock animals. Inasmuch as the only marked difference between the data of the stock and the out-cross animals is the increased ratio of anterior to posterior abnormalities in the back-cross and back-cross F_2 generations, it is not unreasonable to suppose that the something which these three brothers introduced was a preponderance toward abnormality in the anterior feet.

If this is true, it might be expected that, when an individual with an abnormal right anterior foot is bred to a normal-appearing animal of the abnormal stock, there will be a preponderance of abnormal right feet and of forefeet. In this experiment there were seven matings of this type. These animals produced 52 young, 21 of which were abnormal (Table VIII). Of the abnormalities, 9 were in the right anterior foot, 7 in the left anterior, 2 in the right posterior, and 3 in the left posterior. This is a ratio of 16 anterior to 5 posterior.

There were 23 matings of the type *ffo* × *ffla* (Table VIII). They produced 221 young, 61 of which were abnormal — 18 having abnormal right anterior feet, 21 abnormal left anterior feet, 11 abnormal right posterior feet, and 11 abnormal left posterior feet. In totaling these numbers, it is found that 63.9 per cent of these abnormalities were in the anterior feet, and 36 per cent were in the posterior feet.

TABLE VIII

Matings Involving One Abnormal Foot

Type of Mating	Right anterior	Left anterior	Right posterior	Left posterior	Total anterior	Total posterior	Total right	Total left	Young abnormal	Total Young
ffo × ffra	9	7	2	3	16	5	11	10	21	52
Percentage	42.8	33.3	9.5	14.2	76.1	23.7	52.3	47.5	..	...
ffo × ffla	18	21	11	11	39	22	29	32	61	221
Percentage	29.5	34.4	18.0	18.0	63.9	36.0	47.5	52.4	..	...
ffo × ffrp	4	17	10	12	21	22	14	29	43	117
Percentage	9.3	39.5	23.2	27.8	48.8	51.0	32.5	67.3	..	...
ffo × ffip	2	12	4	10	14	14	6	22	28	101
Percentage	7.1	42.8	14.2	35.7	49.9	49.9	21.3	78.3	..	...

There were 17 matings of the type *ffo* × *ffrp*. These animals gave birth to 117 young, 43 of which were abnormal-footed. Four of the abnormalities were in the right anterior foot, 17 in the left anterior, 10 in the right posterior, and 12 in the left posterior. In this cross 49 per cent of the abnormalities were in the anterior, and 51 per cent were in the posterior, feet.

Eleven matings of the type *ffo* × *fflp* produced 101 young, 28 of which were abnormal. Of these abnormal individuals, 2 had abnormal right anterior feet, 12 had left anterior abnormalities, 4 right posterior, and 10 left posterior abnormal feet. In this cross 50 per cent of the abnormalities were in the anterior feet, and 50 per cent were in the posterior feet.

From the data (Table VI), it is seen that the four feet of the stock mice are susceptible to this abnormality in the order: left anterior, left posterior, right posterior, and right anterior. If, then, an individual bearing a single deformity is bred to an apparently normal individual, it might be expected (if these abnormalities are specific for the different feet rather than general for all feet) that the resulting progeny will vary from the normal percentage for each foot as shown by the eighth line of Table VI, and that the influence of the localization of the deformed foot will manifest itself in the ratio. Since there is a definite sequence of susceptibility to abnormality, it also might be expected that the influence of a left anterior foot in such a cross will affect the ratio more than a right anterior foot. In Table VIII, however, it is found that this is not necessarily true. It is found rather that introducing anterior abnormality into such a cross increases the percentage of anterior abnormalities, and that posterior abnormality introduced in this way tends to bring the ratio of anterior to posterior abnormality back to that of the stock animals.

Since the left side (all types of mating) is dominant over the right side, and since one left foot when it is the only abnormality in the cross does not appear to make any appreciable difference in the number of left-foot abnormals produced, Table IX, which is the record of those matings in which each parent had a left-foot abnormality, was compiled in an attempt to determine whether a double dose of "leftness" would produce young which would show a variation from the ratio of the stock mice.

TABLE IX

MATINGS IN WHICH EACH PARENT HAD A LEFT-FOOT ABNORMALITY

TYPE OF MATING	Right anterior	Left anterior	Right posterior	Left posterior	Total anterior	Total posterior	Total right	Total left	Young abnormal	TOTAL YOUNG
ffl × ffl	7	15	7	6	22	13	14	21	35	119
Percentage	20.0	42.8	20.0	17.1	62.8	37.1	40.0	59.9	..	...

This table is computed from the young of 13 matings, from which 119 progeny were obtained. There were 35 abnormal feet among these animals. Of these, 20 per cent were right anterior and 20 were right posterior, while 42.8 were left anterior and 17.1 were left posterior. In totaling these right and left, the ratio is found to be 40 per cent right to 59.9 left. The similarity between this ratio and that of the stock mice (39.8 per cent right to 60.1 left) is striking.

From these data it is evident that the inheritance of this abnormality is not specific for the four feet, but that apparently there are modifiers present, the manipulation of which changes the ratio of anterior to posterior abnormalities.

These data tend further to show that the Bagg albino females used in the out-cross introduced a modifier or modifiers which changed the localization of the abnormalities in an anterior direction.

THE RELATION OF FOOT ABNORMALITY TO EYE ABNORMALITY[7]

The data for the abnormal-footed individuals, showing as they do departure from equality in the numbers of right and left side abnormalities, suggest the questions:

[7] It is contemplated to make a study of the brains of a relatively large series of mice showing distinct eye abnormalities. This study is to embrace more particularly the thalamic and tectal regions to ascertain the possibility of a correlation between eye defects and receptive centers. The preparations of sections serially cut for the study of cells and fiber paths are under way.

1. Does the number of abnormal eyes occurring on the right side differ from the number occurring on the left side in this stock?

2. Does out-breeding alter this ratio in any way?

3. Does the location of an abnormal eye have any relation to the side upon which abnormal feet occur when they happen in the abnormal-eyed individuals?

The abnormal-eye data, which were derived from the same matings as those from which the abnormal-foot data were computed (Table X), show that in the 1922 young born to stock animals there were 1212 abnormal-eyed individuals. That is, 63 per cent of the young were abnormal-eyed. Of these abnormal individuals, 50.8 per cent had abnormal right eyes, 40.4 had abnormal left eyes, and 8.8 were abnormal in both the right and left eyes.

These data are in striking contrast to those of the back-cross generation. In this division of the experiment there were 729 young, 217, or 29.7 per cent, of which had abnormal eyes. This is, as was expected, almost one half of the frequency with which the abnormalities occurred in the stock mice. Of these deformities, 49.3 per cent were in the right eye, 45.6 per cent in the left eye, and 5 per cent of the young were abnormal in both eyes.

TABLE X

Distribution of Eye Abnormalities

Type of Mating	Abnormal right eye	Abnormal left eye	Abnormal both eyes	Number of young	Young with abnormal eyes	Percentage of young abnormal-eyed
Stock.....	616	490	106	1922	1212	63.0
Percentage.....	50.8	40.4	8.8	....	....	....
Back-cross.....	107	99	11	729	217	29.7
Percentage.....	49.3	45.6	5.0	....	....	....
Back-cross F_2.....	59	56	12	318	127	39.9
Percentage.....	46.4	44.1	9.4	....	....	....

It is found here that out-breeding this abnormal stock to normal females introduced something (probably the gene F), which reduced the number of abnormalities almost exactly by one half, but that the small preponderance of right-eye abnormality over left is retained in almost the same ratio in which it occurred in the stock mice.

The figures for the back-cross F_2 generation of this stock (Table X) show that the reduction in abnormalities, after having been made in the back-cross, is retained in following generations. This is not true of the foot abnormality, as has already been pointed out. In this stock there were 318 young, 127, or 39.9 per cent, of which were abnormal-eyed. This again is slightly over one half of the old stock ratio. The preponderance of right is again held in the ratio of 46.4 per cent to 44.1 per cent, which approximates that of the back-cross generation, although these figures probably mean that equality is indicated.

Of the 1922 stock mice 1212, or 63 per cent, were abnormal-eyed. Of these abnormal-eyed young, 288 also bore an abnormal foot. The distribution of these abnormal feet coincident with an abnormal eye follows, in general, the same law as that of the abnormal feet alone. That is, the right eye is abnormal simultaneously with the left feet more than with the right. This is to be expected, however, inasmuch as the abnormal feet occur in the ratio of 60 abnormals on the left side to 40 on the right. This condition is also found in the case of the left eye, where the left feet are coincidently abnormal with the left eye more than are the right feet.

In the back-cross generation, there were 729 young, 217 of which had abnormal eyes. Of these 217 abnormal-eyed individuals, 81, or 37.3 per cent, bore an abnormal foot. Here again the left feet are more often coincidently affected with both the right and the left eyes than are the right feet, the condition being more marked in the anterior limbs. This is to be expected since the ratio of anterior to posterior abnormal feet changes from equality in the stock mice to a 75 to 25 ratio in the back-cross generation.

In the F_2 back-cross generation, there were 318 young, 127, or 39.9 per cent, of which were abnormal-eyed. Of these 127

abnormal-eyed individuals, 80 also bore an abnormal foot. This generation diverges from the others in that the right anterior foot is coincidently abnormal with the right eye more often than is the left anterior. The customary predominance of the left abnormality holds, however, in the feet coincidently abnormal

TABLE XI

Distribution of Foot and Eye Abnormalities

Type of Mating	Abnormal eye coincident with abnormal foot	Right eye coincidently abnormal with				Left eye coincidently abnormal with				Number of abnormal eyes
		Right anterior	Left anterior	Right posterior	Left posterior	Right anterior	Left anterior	Right posterior	Left posterior	
Stock	288	36	38	39	53	36	50	40	33	1212
Percentage	23.7	..	..	..	..	..	..	..	..	....
Back-cross	81	10	20	7	6	18	21	13	8	217
Percentage	37.3	..	..	..	..	..	..	..	..	....
Back-cross F_2	80	14	19	2	6	18	24	9	6	127
Percentage	62.9	..	..	..	..	..	..	..	..	....

with the left eye.

One very striking thing about these data is the fact that in the stock mice 23.7 per cent of the abnormal-eyed individuals were coincidently abnormal in one of their feet, while in the back-cross and back-cross F_2 generation, this percentage increases to 37.3 and 62.9 per cent, respectively. This indicates that, while the actual percentage of abnormal-eyed mice has been reduced one half by out-crossing to normal females, the individuals which were abnormal-eyed in the latter two generations are increasingly likely to be abnormal in their eyes and feet coincidently.

It may be concluded from these data that:

1. There is a tendency toward equality in the number of abnormal eyes occurring upon the right and left sides in all three stocks.

2. There is apparently no causal relation between abnormal eyes on either side and the location of the coincidently abnormal feet.

3. By recovering the abnormality from the out-cross, factors favorable for abnormal eyes occurring alone have evidently been lost, and the eye and foot abnormalities in the same individuals seem in some manner to have been brought together or concentrated.

TABLE XII

SHOWING THE PERCENTAGE OF ABNORMAL-FOOTED YOUNG

TYPE OF MATING	Number young	Abnormal-footed individuals	Percentage of young with abnormal feet	Individuals abnormal in more than one foot	Percentage of abnormal individuals, abnormal in more than one foot
Stock.....	1922	356	18.5	68	19.1
Back-cross.....	729	124	17.0	40	32.2
Back-cross F_2...	318	86	27.0	32	37.2

The effect of this concentration is very marked when the case of the abnormal feet alone is considered (Table XII). In this table it is shown that of the 1922 stock animals 356, or 18.5 per cent, had abnormal feet. Of these 346 animals 68, or 19.1 per cent, were abnormal in more than one foot. The data for the back-cross show that of the 729 young 124, or 17 per cent, were abnormal. Of these 124 deformed young 40, or 32.2 per cent, had multiple abnormalities. In the back-cross F_2 generation, 86 out of 318 young were abnormal (27 per cent), and of these 32, or 37.2 per cent, were deformed in more than one foot.

It has been shown earlier in this paper that, although the character "abnormal foot" behaves as hypostatic to normal, animals homozygous for the deformity do not have 100 per cent abnormal-footed young. Of the 1922 stock animals (Table XII) 356, or 18.9 per cent, were abnormal in one or more feet. If this percentage is taken for the degree of manifestation for homozy-

gous parents, it is apparent that the back-cross generation should throw 9.2 per cent abnormal-footed young, provided the normal unrelated females had introduced nothing into the cross which affects the ratio.

From the table, however, it is seen that instead of 9.2 per cent, the abnormal animals appeared in 17 per cent of the individuals of this generation. Evidently something was introduced by the normal females which caused the deformity to make itself apparent in about twice the expected number of cases.

If, then, the ratio of abnormal to normal has been changed by out-crossing, the effect of the change should be felt in the F_2 back-cross generation when abnormal animals are chiefly selected for breeding. Table XII shows that in this generation 27 per cent of the young were abnormal. This is not quite the expectation of 34 per cent computed upon the percentage of abnormality in the back-cross generation and does not approximate 37 per cent if the expectation is computed on the basis of twice as many abnormals as appeared in the stock animals. On the other hand it is far in excess of twice the 9.2 per cent which was originally calculated for the back-cross.

From these data it may be concluded that out-crossing this abnormality introduced factors which enabled the abnormality to manifest itself in a ratio which is distinctly greater than that of the original stock.

Since both the eye and the foot defects are hypostatic to normal and since they both overlap normality at one extreme of their variation, the question arises: Are they different manifestations of the same developmental process, or are they distinct deformities and independent of each other?

In Table XIII the data for both these defects are brought together. From this it is seen that of the 1922 animals in the abnormal stock 356, or 18.5 per cent, had abnormal feet and 1212, or 63 per cent, had abnormal eyes. It is apparent from this that the conditions necessary for the manifestation of abnormal eyes are over three times as likely to occur as are these necessary for the production of abnormal feet.

Taking 18.5 per cent abnormals as the normal degree of

TABLE XIII

SUMMARY SHOWING A COMPARISON OF OBSERVED AND EXPECTED ABNORMALITIES

	Stock		Back-cross		Back-cross F_2	
Total number of animals	1922	.....	729	.....	318	.....
Total number abnormal-footed individuals....	356	18.5%	124	17.0%	86	27.0%
Total number abnormal-eyed individuals.....	1212	63.0%	217	29.7%	127	39.9%
Total number normal-footed individuals....	1566	.....	605	.....	232	.....
Total number normal-eyed individuals.....	710	.....	512	.....	191	.....
	Observed	Expected	Observed	Expected	Observed	Expected
Abnormal eye coincident with abnormal foot..	288	224	81	37	80	34
Abnormal eye coincident with normal foot....	924	988	136	180	47	93
Normal eye coincident with abnormal foot..	68	131	43	87	6	52
Normal eye coincident with normal foot....	642	579	469	425	185	139

occurrence of the abnormal feet in the stock strain, the number of abnormal feet which will occur may be computed for any one of the four possible combinations of these two defects, namely: (1) abnormal eye and abnormal foot; (2) abnormal eye and normal foot; (3) normal eye and abnormal foot; (4) normal eye and normal foot.

If this line of thought is followed, it might be expected that, provided the two abnormalities are different entities, 18.5 per cent of the 1212, or 224, of the abnormal-eyed individuals will also be abnormal-footed, and that 81.5 per cent of 1212, or 988, will bear the abnormal eye alone.

From the table it is seen that instead of 988 only 924 of the 1212 were abnormal in their eyes alone, but that the observed

number of abnormal eyes coincident with an abnormal foot is well in excess of the expected number — 288 as against 224.

After the same manner it may be estimated that 131 of the 710 normal-eyed young will have abnormal feet, and the 81.5 per cent of 579 will be normal in both eyes and feet. The latter type is slightly in excess of the observed number. The observed number of animals with normal eyes and abnormal feet is well below the expectation — 68 as compared with an expectation of 131.

In the data for the back-cross, it is seen that much the same sort of thing is true here also, the observed animals with abnormal eye and abnormal foot being almost twice as frequent as expected. The number of animals with normal feet in conjunction with abnormal eye is much lower than calculated.

This same condition holds true for the back-cross F_2 as well.

From these data it does not seem unreasonable to conclude that the abnormalities which occur in the feet and eyes are manifestations of the same general genetic change; namely, a developmental arrest which is operative to the greatest effect in the region of the eyes and then in the left and right feet.

This developmental arrest appears to be due primarily to the extravasation of blood in the subepithelial connective tissues of the developing foetuses. The degree to which the deformities develop depends entirely upon the age at which they start and the region in which they start. The reason for their settling largely in the eye is due probably to the prominence of this organ in development and because of its innate complexity; and any small variation from normal may well make itself evident macroscopically.[8]

CONCLUSIONS

1. Changes in the germ-plasm may be effected by X-rays.
2. These changes may be inherited.
3. The abnormalities in this particular case are hypostatic to normal conditions.

[8] The available embryological material pertinent to these studies, fixed, sectioned, and stained after approved methods, is being accumulated with a view of making histogenetic studies of the abnormalities here discovered.

4. "Low incidence strains" may be segregated from time to time.

5. "High percentage strains" may for a time show a high percentage of abnormal animals, but all in turn throw strains which tend toward normal.

6. Having reached normal, strains do not necessarily breed true to normal.

7. The stock bred *inter se* would not therefore "lose" the abnormality.

8. There is great variation in degree of abnormality. At one end of its manifestation it overlaps normal.

9. At least 50 per cent of the genetically abnormal animals are normal in appearance. Further histological and embryological study will probably add to our information on this point.

10. The observed ratios cannot be explained on the basis of a single gene.

11. If both parents are abnormal in appearance, the probability of abnormal young is greater then if one or both are "normal overlaps."

12. The digital abnormality appears most frequently in the left anterior foot.

13. Sixty per cent of the foot abnormalities are on the left side.

14. In the "stock" mice the abnormalities are equally distributed between anterior and posterior feet.

15. Out-crossing the abnormals to normals (Bagg albino strain) increases the percentage of anterior abnormality, suggesting that modifiers for localizing the abnormality are introduced by the normal strain used.

16. Out-crossing the abnormality to normal Bagg females probably introduced plus modifiers which have increased the proportion of normal feet.

17. Sixty-three per cent of the stock animals had abnormal eyes of the type described by Little and Bagg as *hh*.

18. Eye and foot abnormalities either are due to the same general genetic change or are in some way linked together in inheritance.

19. If they are the same character, they may be different manifestations due to variation in the time of greatest influence of the gene upon the developing embryo.

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PART II: PERIPHERAL MOTOR NEURONES

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INTRODUCTION

IN PART I of this paper a study has been made of the genetic behavior of a group of abnormalities which appeared in the descendants of a race of mice, the ancestors of which were subjected to a light dose of X-rays (Little and Bagg, 1923, 1924).

One of the most outstanding of these defects is a developmental arrest which affects the feet and legs of the young of these animals, and which manifests itself in a variety of malformations that overlap the normal condition on one end of their variability, and on the other extreme produce young animals with grossly deformed paws and legs.

Since it is known that one of the more usual effects of X-ray irradiation is the alteration of the nervous system of the young (Bailey and Bagg, 1923; De Nobele and Lams, 1925), and since in development and normal function a correlation of the nervous system with the tissues of the limbs is postulated, it seemed desirable to undertake a study to ascertain whether or not the deformities of the limbs are due to improper development of the spinal cord, thus depriving the limb buds and limbs of normal innervation during their *anlagen* and developmental stages and resulting in structural defects in the adults.

Part II of this contribution records a study of the peripheral motor neurones in a series of mice which had more or less pronounced leg deformities. An investigation of peripheral sensory neurones, more particularly the dorsal root ganglia, in mice presenting paw and leg abnormalities is reserved for a later date.

MATERIAL AND METHODS

The spinal cord enclosed within the dura, together with the brain stem to the level of the midbrain and the proximal portion of the lumbo-sacral plexus, was removed from the dorsal side. The nerve roots of the several segments of the spinal cord were retained in sufficient length to enable ready recognition. The spinal cord thus removed was moistened with normal salt solution and transferred to a clean slide with the ventral aspect of the cord against the slide. The lumbo-sacral nerves were then spread fan-shape and tied to the slide by means of fine thread. By applying slight tension to the brain stem, the cord was extended in an approximately straight line. When this alignment was attained, the central end was tied to the slide by means of thread. The spinal cord attached thus, cephalad and caudad, was maintained in this position on the slide through the successive steps of histologic technique.

The cords studied were fixed in trichloracetic-mercury-alcohol mixture (Huber, 1927), dehydrated in absolute alchohol, cleared in xylol, and permeated in paraffin of successively increasing degrees of melting point — 45°, 52°, 54°. In order to facilitate study, complete serial sections were made. Certain of the series were cut transversely, and other series were cut longitudinally in the coronal plane.

In preparing the cords which were to be cut transversely the procedure was as follows: After fixation and partial dehydration the cords were cut into equal segments of approximately one centimeter in length. These segments were then arranged on a slide in close lateral proximity with the ventral aspect of the cord against the slide, and the central end of each segment in alignment with the other several segments. In this arrangement

they were tied to the slide by several windings of a fine thread and were then carried through hydration, clearing, permeation with paraffin, and were embedded in paraffin in the same arrangement and alignment. Each stroke of the knife thus cut five or six sections, which were fixed to the slide in serial arrangement. There is by this method slight loss of tissue at each cross-section level at which the cord is cut into successive segments.

In preparing the longitudinal series, the cords were arranged on a glass slide coated with a thin film of glycerine, the ventral aspect of the cord resting upon the slide. Embedded thus in paraffin, the ventral side of the cord was presented to the knife when the paraffin block was placed in the microtome.

Both cross and longitudinally cut series were sectioned into respective series at a thickness of from 50 micra to 30 micra, the latter thickness becoming standard as the work progressed. These series were cut on the sliding microtome, the longitudinal sections embracing the entire length of the spinal cord. The sections as cut were arranged serially on slides to which they were fastened by means of albumin fixative.

After removal of the paraffin, the sections were stained in a dilute aqueous solution of toluidin blue, differentiated in aqueous solution of lithium carbonate and alcohol and mounted in balsam. Treated by this method, the large multipolar cells of the spinal grey were brought very clearly to view. The multipolar cell bodies presented a relatively deep blue coloration of the Nissl granules. Long segments of the major dendritic branches were evident in the preparations.

The longitudinally directed sections were found to be especially useful in the study of the cell bodies of the peripheral neurones. In such sections serially arranged, it was an easy matter to obtain a survey of the entire peripheral motor system of the spinal cord. Since the series of sections began on the ventral aspect of the spinal cord and of the ventral grey columns, the level at which any section passed through the grey column is readily calculable. Inasmuch as the sections in the several longitudinal series extended from the medulla to the cauda equina, there was encountered no loss of substance such as pertained to the

transversely cut cords, and all cell counts may be relied upon as giving the full number of cells.

Thirty-three spinal cords were prepared and studied. These were sectioned as shown in Table I.

Type of cord	Cut longitudinally	Cut transversely
Normal	7	2
Abnormal	5	6
Operated	8	5

The normal cords were taken from normal Bagg albino mice. This strain of mice is closely related to the abnormal strain in that abnormal males have been out-crossed upon two different occasions to females of the normal Bagg stock. The animals which were operated upon were selected from this same stock of normal Bagg albinos. All animals used were adults at the time they were killed and their spinal cords removed.

THE GREY MATTER OF THE SPINAL CORD OF MAMMALS

The spinal cord of vertebrates is readily separable into—

A) White matter, consisting of ascending and descending nerve tracts.

B) Grey matter, which is composed of —

1. The cell bodies of motor neurones with their dendrites and axones.
2. Neurones of other nerve cells, the axones of which are distributed largely within the central nervous system.
3. Axones and collaterals of axones terminating within the grey matter.
4. Sustentacular tissue, largely of ectodermal origin.

The relation which these two portions of the cord bear to each other varies greatly in the different vertebrate forms. In mammals as compared with lower vertebrates, the proportion of grey to white matter increases in favor of the white, so that one may generalize and state that the increase in the relative size of the cords in higher forms is due chiefly to the increased

number of ascending and descending fibers in the cord. If exact measurements are made, it is found that the proportions of the white and grey matter vary in different mammals, and also within different species of the same class. Measurement of the size of the animal must also be taken into account in examinations of this kind.

E. deVries (quoted from Kappers, p. 1120) in comparing the cords of smaller and larger animals states that "the white increases in the cross-section as the cube and the grey substances as the square," as the total size of the animal increases.

In all forms lower than the amphibians, the relation of grey and white matter is fairly constant throughout the cord. However, with the appearance of limbs, as in the frog, enlargements arise in those regions of the cord which send innervation to the appendages. The size and extent of these enlargements vary directly as the size and extent of the musculature which they innervate. A striking example of this is found in the reptiles, in which form there are three types of cords.

1. In the sphenedons (and crocodiles which have both trunk and extremity musculature) cervical and lumbar enlargements are well developed.

2. In the snakes, where the extremities are lacking, there are no cervical or lumbar swellings.

3. In the turtles, which have no thoracic muscles but do have musculature for the neck, tail, and extremities, the cord is strikingly thin in the thoracic region, but is well developed in the cervical and lumbar regions (Kappers, 1920).

In mammals there are wide variations in the shape of the cord which are readily and directly correlated with the development of the musculature. For instance, in the whale the lumbar enlargement is lacking, while the cervical enlargement is well developed. In the kangaroo, the greater musculature of the posterior extremities manifests itself in the larger swelling of the cord in the lumbar region.

Since these enlargements correspond to the regions where the large nerve trunks from the muscles of the extremities join the cord, it is not surprising to find that these swellings are co-

incident with the localization in the ventral grey of the motor neurone cell bodies, the axones of which form the nerve fibers making up the ventral roots of the spinal nerves.

Microscopic study of various regions of the cord reveals at once the fact that the cell bodies of the motor neurones of the spinal grey are divisible into several groups and columns, two of which are relatively constant:

1. A mesial group which occupies that region of the ventral horn adjacent to the ventral median fissure, and which extends practically throughout the entire length of the cord.
2. A lateral group which manifests itself in the cervical and lumbar enlargements, and which is located lateral to the mesial group. The addition of this group in specific and somewhat restricted regions causes the cervical and lumbar swellings.

The mesial group, extending as it does throughout the cord with the possible exception of the fifth lumbar and first sacral segments, is generally conceded to contain the cell bodies of the peripheral motor neurones, the axones of which innervate the musculature of the trunk.

The motor neurone cell groups of the lateral column of the ventral horns fall into four main cell columns or groups presented here, as outlined by Bruce in his topographic atlas of the spinal cord:

1. Ventro-lateral (4–8C; 2L–2S).
2. Dorso-lateral (3–8C; 2–5L, 1–3S).
3. Retro-postero-lateral (8C–1T; 1–3S).
4. Central (2L–2S).[1]

In the study of the finer localization of the peripheral motor neurone cell bodies for the innervation of special muscles or muscle groups of the extremities, the work has been largely upon the human spinal cord. Such observations may here be grouped under the following considerations:

[1] See on this subject: Hepburn and Waterson (1904), Cunningham (1877), Waldeyer (1888), Kaiser (1891), Collins (1894), Van Gehuchten (1898, 1899), Hatschek (1896a-b), Marinesco (1892, 1898), Sano (1897, 1898), Parhon and Goldstein (1901 a, 1901 b), Bikeles (1904, 1905).

1. The cords of humans who had suffered amputations of various kinds: Van Gehuchten (1898), Sano (1897, 1898), Collins (1894), Bikeles (1904, 1905), Campbell (1896), Dickson (1873), Dreschfeld (1879), Edinger (1882), Genzmer (1876), Hayem (1873), Dejerine and Mayer (1878), Kahler and Pick (1880), Marinesco (1898), Parhon and Goldstein (1901 a and b), Taft (1920), Van Gehuchten and DeBuck (1898 a and b).

2. Studies made of the cord after death from musculature atrophy: Kanai (1914), Friedreich (1873).

3. Studies of the cords of Abrachii: Curtis and Helmholtz (1911), Elders (1910).

4. Experimental studies in which nerve roots were sectioned or muscle tissue removed: Coghill (1913, 1924, 1926), Shorey (1909), Detwiler (1926), Van Gehuchten (1898), Warrington (1898).

From these researches, it is evident that the degeneration changes in the cord observed by certain people (after cases of amputation) are not always confirmed by the observations of others. From the evidence available, however, it is clear that the loss of large bodies of muscle by amputation, through developmental failures as in abrachii, or by means of operations performed on the developing embryo, all have very definite effects upon the shape of the grey matter in the region of the cord which normally supplies the motor nerves to the muscles which are absent.

From the combined work of investigators in this field, it may be concluded (quoting in substance Kapper) that: The finer localization is such that the cells of origin for the most distal muscles are derived from the most ventral part of the perivisceral division of the myotome, the ventral division thus being supplied by the more dorsal neurones. Thus the cell group, the neuraxes of which supply pectoralis major (a ventral myotome derivative), lie dorso-lateral to those for latissimus dorsi, while the cells of origin for fibers to the arm and hand lie dorsal and lateral to those for pectoralis major. The position of the cells for the fingers in nucleus retro-postero-lateral 8C–1T explains the striking lateral extension of the anterior horn in the

8th C segment of primates. The localization for the lower extremities is similar to that of the upper, although they are not so pronounced and definite. A satisfactory explanation for this reversal is wanting; there is uncertainty whether it is owing to primary effects or to secondary changes due to neurobiotaxis.

From this it may be conjectured that: 1. The cell bodies of the peripheral neurones supplying the muscles associated with body statics are situated ventro-medially in order to lie in closer relation with the caudal continuation of the medial longitudinal fasciculus and with the vestibulo-spinal tract; 2. The cell bodies of the peripheral neurones innervating the muscles concerned with the highly organized activities of hand and foot are situated dorsally in close proximity to the great descending paths coming from higher centers, which govern more particularly synergic muscular action, especially through the rubro-spinal path.

These observations pertaining to the topographic relations of the cell bodies of the peripheral motor neurones of the spinal cord, as very briefly reviewed here, are in their main phase applicable to the study of the peripheral motor mechanism of the spinal cord of mammals in general and more particularly to the study of the higher mammals. Such differences in detail as may be revealed by special study of the spinal cord of any mammalian form may be correlated more or less definitely with specialized development of the muscular system.

THE SPINAL CORD OF THE MOUSE

To facilitate the portrayal of the spinal cord of the mouse and more particularly the numbers and topographic relations of the cell bodies of the peripheral motor neurones as found in the ventral grey columns, there are shown here a number of figures sketched at uniform magnification and drawn from cross-cut and longitudinally cut series. In these sketches the white matter and the grey matter are merely outlined, emphasis being given to the motor cells found in the grey matter of the respective sections. An attempt has been made to represent accurately the number of cells falling to each section. To facilitate figure clearness, however, slight latitude was taken with reference to cell size in the

hope that in the reduction necessary for figure reproduction the cells sketched should not be lost to view.

The cross-section series, Figures 56 and 57, are drawn from a series of cross-sections of the spinal cord of the mouse cut at a thickness of 30 micra, and representing levels approximately one millimeter apart. In making this statement cognizance is not taken of the fact that there is a slight loss of tissue in cutting the cord into several segments, as was done in this procedure. That with this method the loss of tissue is appreciable in a spinal cord like that of the mouse can be ascertained by computing the number of sections in the series and multiplying the same by the section thickness. This product, when compared with the length of an uncut cord, shows the tissue lost. However, the figures chosen for the several sketches are in sufficiently close approximation to enable the observer to discern the form and relation of the ventral and dorsal horns of the grey matter at successive levels and to enable comparison of the relative proportions of the grey and white matter at the various levels. Of the several sketches in Figures 56 and 57 sketches 1 to 8 fall to the cervical region, sketches 9 to 21 to the thoracic region, and sketches 22 to 30 to the lumbo-sacral region.

When Figures 56 and 57 are examined, it is seen that, beginning with sketch 1, the mesial groups are well marked, and that they continue throughout the length of the cord, being present in every level sketched. This is in marked contrast to the cells of the lateral columns which begin in the first and extend through the eight sketches of the cervical region. These cell groups are not found in the sections through the thoracic region, but reappear in the twenty-second section and continue to the last level shown.

In certain of the cervical sections the cell groupings described for humans are well marked. For example, in the fifth sketch, in addition to the dorso and ventro-mesial groups, the ventro-lateral, dorso-lateral, and post-dorso-lateral groups are well marked. If the series is examined above and below this section (fifth sketch), it will be seen that the lateral groups begin in the first section and gradually increase to the fifth section, below which they gradually diminish until in the ninth section they have disappeared, and the

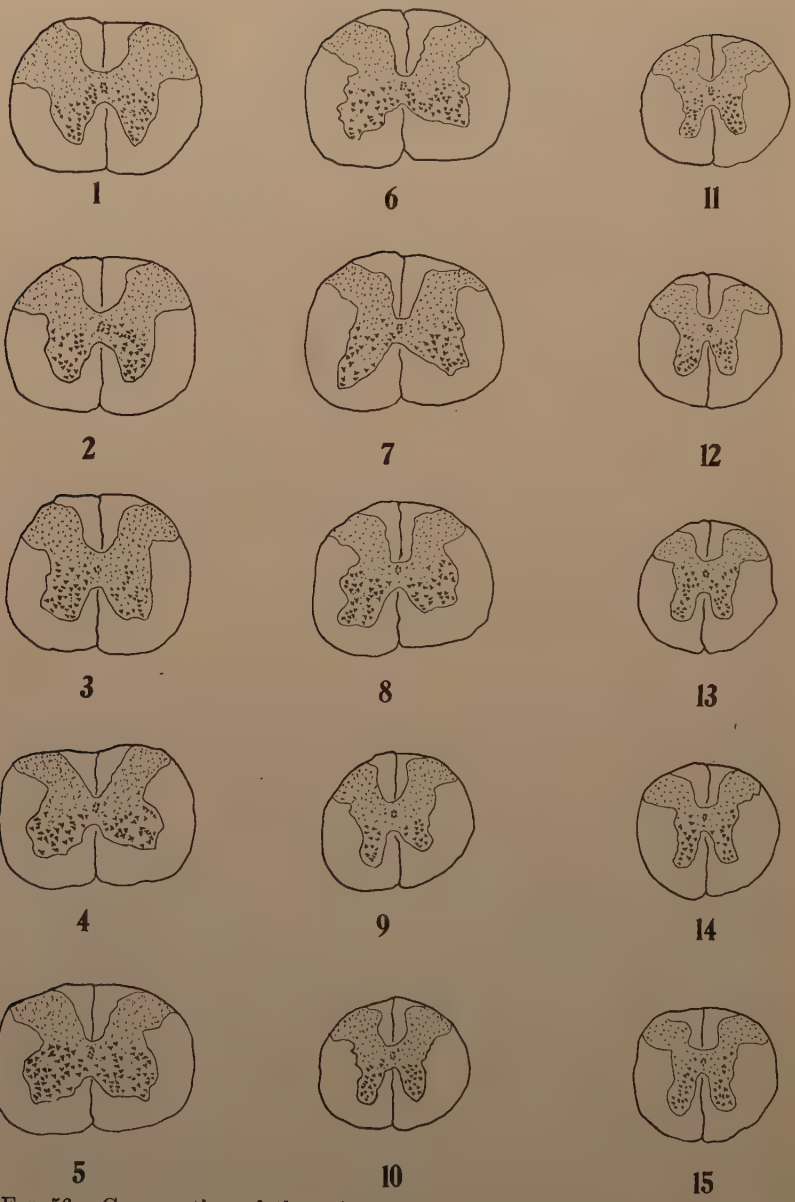

FIG. 56. Cross-section of the spinal cord of the mouse at one-millimeter intervals

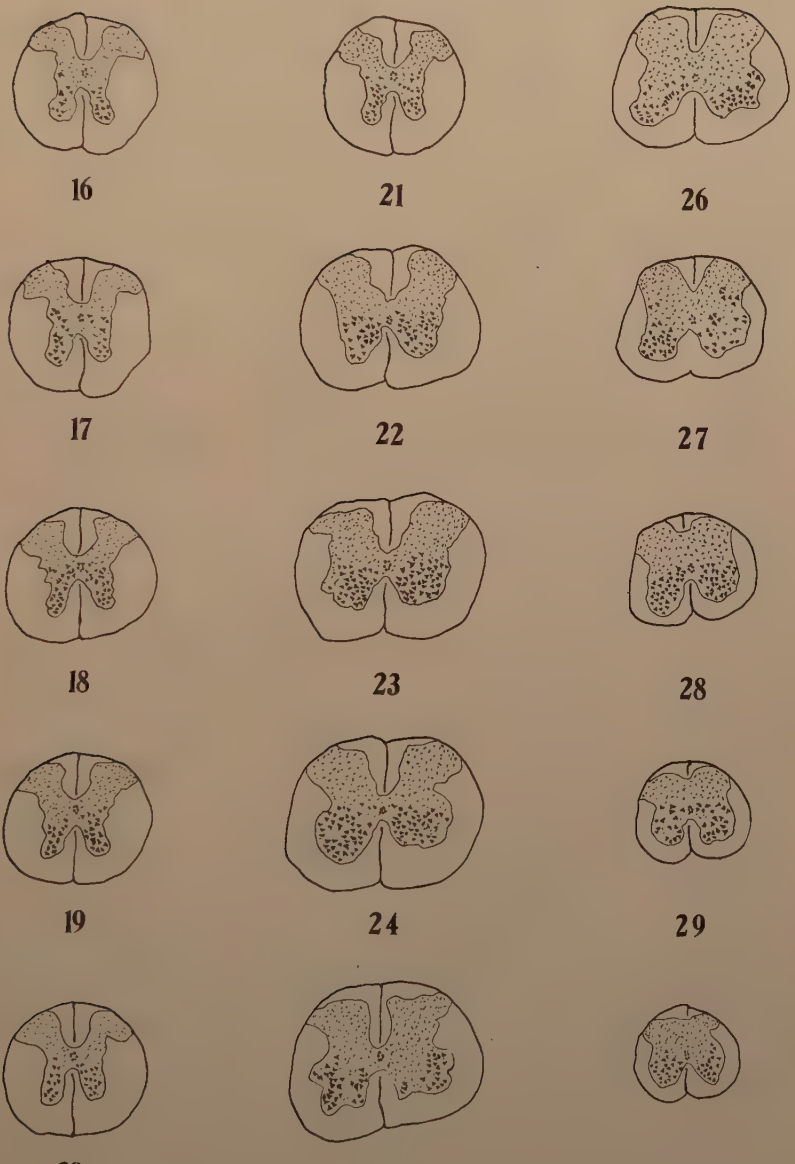

FIG. 57. Cross-section of the spinal cord of the mouse at one-millimeter intervals

cord takes on the contours of the thoracic region. These sections also demonstrate the impossibility of judging the number of cells on the two sides of the cord by counting those appearing in any one section. This is also true when cell columns are studied, since a group may be well marked on one side and entirely absent on the other.

Sections 9 to 21 inclusive show the relative uniformity of the thoracic region. Here the mesial cell groups are the only ones which are present.

Beginning with the twenty-second section and extending through the last section sketched, the lateral columns again appear, grow larger, and diminish. Here, as in the cervical enlargement, the cell groups vary on the two sides of any one section, being generally more closely grouped and less distinguishable than the nerve cell columns in the cervical region.

Figure 58 presents a drawing of nearly the entire length of the spinal cord of the mouse, portrayed in four successive segments. The drawings were made from longitudinally cut series, the sections of which were cut at a thickness of 30 micra. The series was cut by beginning ventrally. Twenty sections of this series contain practically all the cell bodies of the peripheral motor neurones of the spinal cord. The entire left column of the figure and nearly all the right column were drawn from one section, while the middle columns were drawn from an adjacent section. The several parts of Figure 58, when thought of as forming a continuous figure, show very clearly the ventral grey columns bordered by the white matter of the respective halves. They portray clearly the cervical and lumbar enlargements of the ventral grey columns consequent to the great increase in the number of the motor neurones destined to innervate the musculature of the extremities. There is no loss of substance in sections of longitudinal series, since they extend without interruption from the medulla to the conus medularis. In the longitudinally cut series an attempt was made to cut the two sides of the cord symmetrically. Experience has shown this to be difficult. Only a slight rotation of the cord on embedding in paraffin (so that the grey column in one half of the cord is met 3 or 4 sections of 30 micra thickness before that found in the other

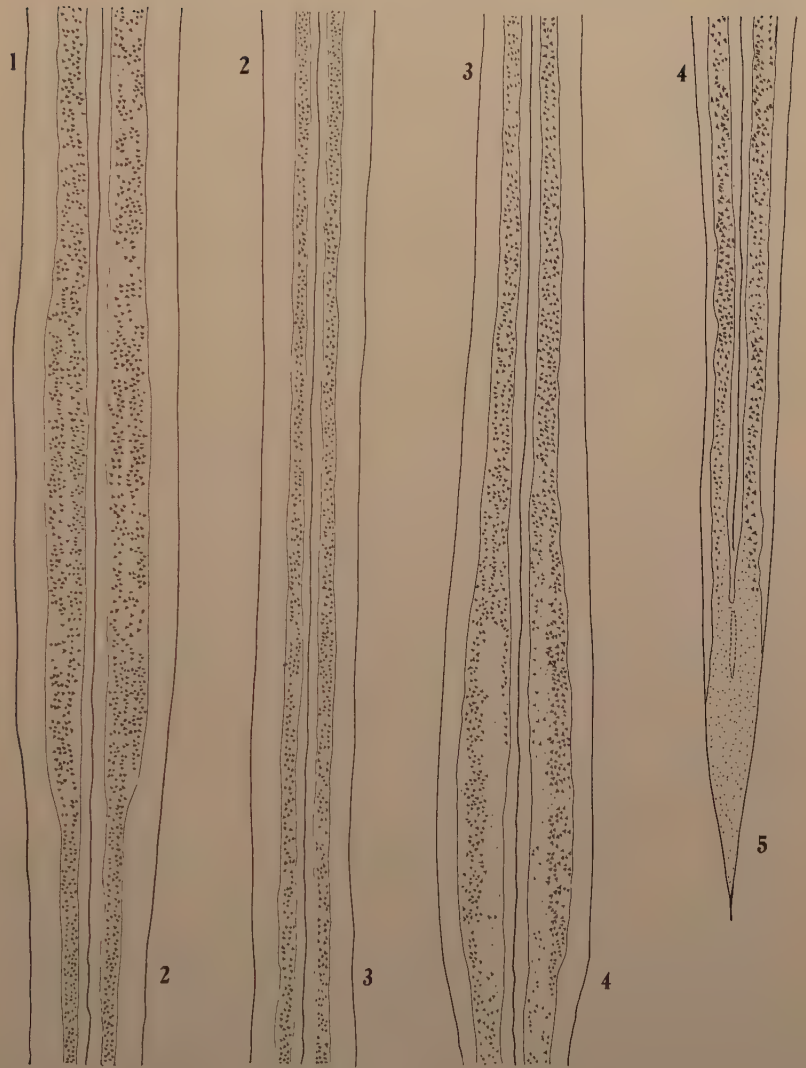

FIG. 58. Coronal section through the ventral cell columns of the spinal cord of the mouse

half is met) makes an appreciable difference in the symmetry of the two sides — assuming that the ventral grey columns of the two sides of the spinal cord are symmetrical. Even such slight difference in the symmetry of the two sides makes it difficult to judge accurately in any one section the comparative number of the motor cells in the two ventral grey columns. However, a slight want of symmetry of the ventral grey columns on the two sides can only be regarded as desirable in making a total count of the motor neurones. Because of this discrepancy in the number of cells on the two sides of the cord in any one section, a comparison of the numbers found is not possible until all the motor cells of a segment have been counted.

MOTOR NEURONE CELL COUNT

In an attempt to determine whether or not the deformed musculature of abnormal-footed animals is correlated in any way with the motor portion of the spinal cord, cell counts were made of the motor nerve cells in the ventral horns of the spinal cords of a number of mice.

The first counted were taken from normal Bagg albino stock. These animals were from the same stock as were the females to which the abnormal-footed males had been out-crossed on two previous occasions. In order to establish a norm, seven of these cords were counted. All these mice were adults when killed, but no selection was made to obtain animals of uniform size.

The cell counts were made from serial longitudinal sections of the cords which had been prepared as recorded in Section 2.

The method of counting used was as follows: Since the cords were cut from the ventral side, the sections lay upon the slides with the right side toward the counter's left. A thin sheet of isinglass, across which lines had been scratched at 2 mm. intervals, was laid upon the slide and the first line adjusted (under the microscope) to lie over some definite portion of the cervical end of the cord which remained constant throughout the series of sections. After the isinglass had been put in position, the right and left sides of the cord were counted separately by 2 mm. segments. The records of the counts made were tabulated upon an especially pre-

pared sheet which was ruled to simulate a cord across which the isinglass graduate had been placed.

Ordinarily all the motor cells were contained in the first 25 or 30 sections of a series. Sometimes, however, the cord had been rotated slightly in embedding in the paraffin, so that all the sections of a series had to be examined.

By counting in this manner, it was seldom that the cell counts on both sides of the ventral median longitudinal fissure were the same in the several divisions of a 2 mm. segment or in the section as a whole. It was only upon adding the totals for the different sections that a similarity in the number of cells contained within the 2 mm. segments on opposite sides of the ventral fissure, or of the two horns taken as entities, became apparent.

Table I represents the average cell count of the seven normal cords which were studied.

It will be seen from this table that the parts of these cords which contain motor nerve cells in the ventral horns were approximately 48 mm. in length. The most striking thing about the count is the closeness with which the number of cells in the 2 mm. segments on the two sides of the median fissure approximate each other. More striking still are the totals for the two sides, which show a difference of only 69 cells.

From this table it is seen that such a cell count corresponds very closely to the general contour of the spinal grey. The cells begin rather abruptly in the cervical region, and rapidly grow more numerous until the fifth 2 mm. segment is reached. They then diminish rapidly until, at a distance of 4 mm. from this segment, the count reaches the number characteristic of the thoracic region.

The number of cells in this region increases slowly as the segments proceed caudally until in the lumbo-sacral swelling (17th 2 mm. segment) there are over 1,000 cells in a 2 mm. length of cord. Caudal to this section, the number of cells diminishes rapidly until at the end of the 24th 2 mm. segment they disappear.

From this average of the counts of several cords is obtained a typical cord which may be taken to represent that of a normal mouse of this stock. It may be said to contain 13,751 motor nerve

TABLE I

AVERAGE OF SEVEN NORMAL CORDS

Left cervical	28	32	Right cervical
	293	286	
	431	489	
	597	606	
	751	771	
2,567	467	467	2,651
Thoracic	247	232	Thoracic
	201	213	
	195	197	
	201	208	
	236	234	
	273	266	
1,642	289	299	1,649
Lumbo-sacral	335	321	Lumbo-sacral
	391	361	
	469	449	
	507	530	
2,087	387	420	2,081
Coccygeal	201	177	Coccygeal
	156	161	
	111	91	
	55	71	
	18	28	
545	4	1	529
TOTAL	6841	6910	

cells, 6,910 of which are on the right side, and 6,841 on the left side of the cord, or approximately 7,000 peripheral motor neurones in the ventral grey column on each side of the spinal cord of the mouse.

This uniformity of the two sides also holds true for larger segments of the cord, as is shown by dividing the Table into cervical, thoracic, lumbo-sacral, and coccygeal segments. In this manner it is found that there are approximately 5,218 cells in the cervical

region, 3,291 in the thoracic region, 4,168 in the lumbo-sacral region, and 1,074 in the coccygeal region.

Small errors may enter into this distribution of cells owing to one or both of two variables:

1. Inconstancy in placing the isinglass graduate so that the number of cells in the first segment will always be approximately the same.
2. Variation in length of the cords which may distort the number of cells appearing in any one segment. (This is especially true of the lumbo-sacral and coccygeal regions.)

It will be seen that, since the cell count of this average normal cord is regular on its two sides, any variation in the cell count of cords of mice which had abnormal feet would be readily detected, since the nerve supply to any one limb will have its motor nerve cells on one side of either the cervical or lumbo-sacral sections as mapped out on the normal cord.

THE ABNORMAL CORD

Five abnormal cords were counted:

	Right side	Left side
1. 1618 hhlffla	7139	7284
2. 1507 hhlffrala	7420	7397
3. 1515 hhoffrala	7463	7596
4. 1240 hhrfflalp	5874	6016
5. 1235 hhrffla	7512	7242

The following symbols are used to describe the deformities of the abnormal animals:

1. *hh* for the head or eye abnormality.
2. *ff* for the foot deformity.
3. *slsl* for the saddled condition of the back.

In this manner *hhrffralp* is used to designate an animal which was abnormal in its right eye as well as in its right anterior and left posterior feet. In some of the early records ff_2a was used to designate individuals which were abnormal in both forefeet.[2]

[2] No counts were made of the motor cells of cross-section series because of the loss of tissue in cutting the cord into segments.

Inasmuch as the cord of 1507 *hhlffrala* was of the same length as the average normal cord, it will be used as an illustration in comparing the abnormal cord with the normal.

TABLE II

1507 hhlffrala

Left cervical	142	142	Right cervical
	405	348	
	580	523	
	712	642	
	819	837	
3,059	401	420	2,912
Thoracic	217	179	Thoracic
	186	164	
	188	189	
	186	156	
	204	200	
	164	177	
	219	247	
1,635	271	294	1,606
Lumbo-sacral	321	319	Lumbo-sacral
	370	433	
	521	597	
	628	635	
2,110	270	282	2,266
Coccygeal	133	138	Coccygeal
	147	132	
	167	180	
	123	136	
616	46	27	613
TOTAL	7,420	7,397	

Since both forefeet of this animal were abnormal, it might be expected that (if there is any difference in the motor innervation to an abnormal foot and to a normal foot) both sides of the cord in the cervical region would show a deficiency of cells when compared with the cervical region of the average normal cord, and

that the other three sections would correspond closely to the homologous segments of the normal cord.

Upon examination the cervical region of the cord of mouse 1,507 was found to contain 5,971 cells as compared with 5,218 cells in the same region of the normal cord. The other three regions were seen to correspond even more closely, there being 8,846 cells in the lower three sections of the abnormal as compared with 8,533 cells in the same regions of the normal cord.

From these data it is doubtful if there is any deficiency of motor nerve supply to the abnormal feet of this stock.

TABLE III

Composite of Five Abnormal Cords

Left cervical	81	81	Right cervical
	363	366	
	510	526	
	684	633	
	756	760	
2,811	417	450	2,816
	199	200	
Thoracic	177	187	Thoracic
	186	199	
	185	204	
	206	214	
	195	224	
1,389	241	264	1,492
	311	280	
Lumbo-sacral	332	355	Lumbo-sacral
	545	525	
	645	588	
2,294	461	466	2,214
	227	249	
Coccygeal	147	161	Coccygeal
	119	82	
	59	60	
	26	27	
587	9	6	585
Total	7,081	7,107	

If a composite cord is made of the counts of the five cords of abnormal mice studied (Table III), it is at once seen that the left side of the cervical region should show the effect of the abnormalities in the left anterior foot of all these mice.

The similarity of the totals of each of the four segments on the two sides of the cord is very striking. When they are compared with the average of the seven normal cords, it is again apparent that there is no deficiency of cells in any one of the four segments or upon either side of the cord.

It will be seen from this table that in any individual cord the closeness with which the cell counts for the two sides of any 2 mm. segment are almost always nearer the number opposite them than they are to the count of any of the other segments.

Wide variations from this general finding are attributable to these facts:

1. The cell columns on the two sides of the cord are not directly opposite each other on the two sides of the cord.
2. Inaccuracy in placing the isinglass squarely across the cord.
3. Inaccuracies in counting.

Usually in cases where there are temporary variations from approximate equality, the deviations are compensated for either just above or immediately below the regions which do not balance numerically.

OPERATED MICE

After it became evident that there was no appreciable and constant difference in the motor cell count of the spinal cords of normal mice and those of mice with leg deformities, it was thought to be pertinent, in the interests of accuracy, to endeavor to determine the precise location of the cell bodies of the motor neurones innervating the musculature of the upper and lower extremities. With this in view nerves of the extremities were severed in the hope of obtaining tigrolysis in the cell bodies of the injured neurones. In certain mice the sciatic on the one side was severed, in others the median and ulnar of one side at the level of the elbow, and in still others the left paw was amputated at the wrist.

It was thought that, should constant and evident tigrolysis obtain in certain groups of motor cells of the lateral columns, a differential count could be made and more careful scrutiny given to such regions of the lateral columns of motor cells of the cervical and lumbo-sacral portions of the spinal cord in the mice with leg deformities. In case cell destruction had obtained, a noticeable difference in the cell count of the affected areas would be noticeable. Such results would indicate the regions of the cords of abnormal animals which could with profit be studied more closely for cell count deficiencies.

Fourteen mice were operated upon under complete anesthesia. Eight had the left sciatic nerve isolated, cut, and a segment removed; three had their ulnar and median nerves severed at the elbow and a segment removed; and three had the left paw amputated at the wrist. Seven of the animals were killed twenty-two days after the operation; four were killed twenty-six days after the nerves were cut; and the three remaining were allowed to live thirty-seven days after the nerves were severed.

The cord of mouse 25 was injured and made useless in the

TABLE IV

List of Mice Operated On

Mouse	Sex	Date operated	Date killed	Time in days	Nerve cut	Sectioned
21	♂	Oct. 9	Oct. 31	22	left sciatic	cross
22	♂	Oct. 9	Oct. 31	22	left sciatic	longitudinal
23	♀	Oct. 9	Oct. 31	22	left sciatic	longitudinal
24	♂	Oct. 9	Nov. 4	26	left sciatic	longitudinal
25	♀	Oct. 9	Nov. 4	26	left sciatic	cord destroyed
26	♂	Oct. 9	Nov. 4	26	left sciatic	cross
27	♂	Oct. 9	Nov. 15	37	left sciatic	longitudinal
28	♂	Oct. 9	Nov. 4	26	left sciatic	cross
31	♂	Oct. 9	Oct. 31	22	left wrist	longitudinal
32	♂	Oct. 9	Nov. 15	37	ulnar and median	cross
33	♂	Oct. 9	Oct. 31	22	ulnar and median	longitudinal
34	♀	Oct. 9	Oct. 31	22	ulnar and median	longitudinal
35	♀	Oct. 9	Nov. 15	37	left wrist	cross
36	♀	Oct. 9	Oct. 31	22	left wrist	longitudinal

process of removing it from the spinal column. Of the remaining thirteen cords, eight were sectioned longitudinally in the coronal plane; five were cut in cross-sections, care being taken to cut longitudinal and cross-cut series in presenting different phases of the experimental series of mice.

The results in this series of observations were disappointing in that definite and conclusive evidence of tigrolysis was not obtained in any one of the thirteen series studied.

The spinal cords in these series were removed as in other series and fixed in the trichloracetic-mercury-alcohol mixture. They were then embedded in paraffin, sectioned, and stained in toluidin blue solution, as described for the other series herein considered. The fixation of the tissue as concerns the cell bodies of the peripheral motor neurones and their stainability in toluidin blue leaves nothing to be desired. In the large motor cells of the respective regions of the spinal cord, where no tigrolysis was anticipated, the coloring of the tigroid or Nissl substance is evident, although it does not appear to be of distinctly granular form when fixed and stained by this method. In those regions of the cervical and lumbosacral cord where tigrolysis was anticipated in the respective series, cells appeared here and there which showed less distinctive staining. Such cells were quite as likely to have a heterolateral position with reference to the operated nerve as to have a homolateral position. Therefore, the deductions to be made on the evidence of tigrolysis in these cords are inconclusive. The evidence pertaining to motor cell destruction consequent to degeneration of the peripheral motor nerves as possibly evidenced by deficiency in motor cell count needs yet to be considered and is here presented in summarized form.

Table V presents the average cell count of the eight longitudinally sectioned cords of this series.

It might be expected, if there is any deficiency of cells due to their being missed in the cell counts because of cell destruction following nerve injury, that the count of the left side would be noticeably lower than the count of the right side, since all the nerves were severed on the left side. A glance at the totals, 6,865 for the left side and 6,968 for the right, shows that this is not the case.

TABLE V

COMPOSITE OF EIGHT OPERATED CORDS

Left cervical	11	11	Right cervical
	240	227	
	394	397	
	588	594	
	627	640	
2,501	641	659	2,528
	275	286	
Thoracic	200	206	Thoracic
	188	200	
	190	186	
	197	199	
	205	222	
	238	238	
1,772	279	289	1,826
	309	304	
Lumbo-sacral	425	425	Lumbo-sacral
	573	571	
	503	493	
2,136	326	303	2,096
	149	155	
Coccygeal	135	135	Coccygeal
	95	113	
	40	74	
	31	34	
	6	6	
456	0	1	518
TOTAL	6,865	6,968	

Since four of the cords were associated with degeneration of the left sciatic, it might also be expected that the left lumbo-sacral region would show a deficiency. This is not confirmed by the data, nor is there any marked deficiency in the left cervical region, which is the site of the motor cells of the four cords with nerve degeneration in the left fore limbs.

It may be concluded, therefore, that there is no apparent cell destruction in cords of this series in which degeneration of one or several peripheral nerves was present.

If the average of the count of the motor cells in the eight longitudinally cut spinal cords of this series is compared with the standard cord for normal mice, and the average of the five spinal cords in abnormal mice, the similarity in number of motor nerve

TABLE VI

NORMAL CORD — AVERAGE OF TWENTY CORDS

Left cervical	34	36	Right cervical
	290	282	
	436	461	
	615	608	
	702	716	
2,601	524	540	2,643
	246	246	
Thoracic	195	204	Thoracic
	190	198	
	193	198	
	213	215	
	227	238	
	257	266	
1,827	306	299	1,864
	343	337	
Lumbo-sacral	470	458	Lumbo-sacral
	568	561	
	452	460	
2,090	257	245	2,061
	151	159	
Coccygeal	123	106	Coccygeal
	72	85	
	29	46	
	16	15	
393	2	3	414
TOTAL	6,911	6,982	

cells in the different segments, both for 2 mm. segments and regional, is striking.

From these data it is evident that there is no marked difference between the cell counts of any pair of the three different types of cord (normal, abnormal, and operated). If, then, the average cord is computed for these twenty cords, a normal cord will be obtained in which the probable error of any mistakes in counting will be minimized. Such a cord is represented in Table VI, which gives the average of 20 cords: 7 normal, 5 abnormal, and 8 operated.

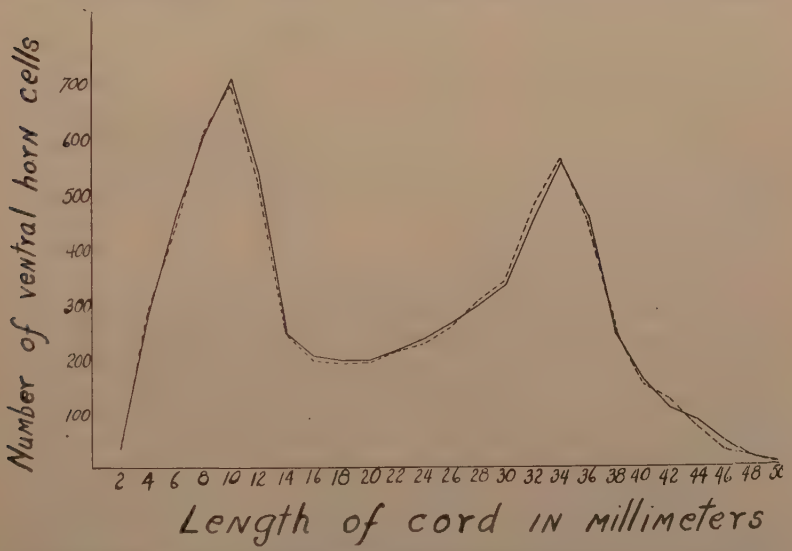

FIG. 59 (Graph I). Curve showing variations in cell counts on the two sides of the cord

If this is compared with the average cords of the normal, the abnormal, and operated mice, it will be seen that there is no marked variation in the corresponding 2 mm. segments, and that the four regional graduations show a similarity which is even more marked.

DISCUSSION OF RESULTS

In the preceding sections an attempt has been made to show, by comparing the motor neurone cell counts of normal mouse cords with similar counts of cords of abnormal-footed animals and also

with the cords of animals systematically mutilated to produce tigrolysis in motor cells of the spinal cord, that there might possibly be some deep-seated nervous defect which lay at the root of the abnormal development underlying the foot abnormalities. The findings have been entirely negative in this respect.

It has been possible, however, to compute from the data accumulated what is apparently a close approximation of the cell bodies of peripheral motor neurones in the spinal cord of the mouse (Table VI).

Graph I (Fig. 59), which tabulates the curve of the cell counts for the two sides of this normal cord, shows a remarkable case of bilateral symmetry in a mammal.

That this curve is not entirely correct, but is weighted slightly by inaccuracies in the technique of counting, is shown by Graph II (Fig. 60), which demonstrates the effects produced by inaccuracies in placing the graduate, and the effects of variability in length of different cords.

The most striking thing brought out by this study is the fact that, although the number of cells in any cord is relatively evenly distributed in the right and left ventral horns, it may vary through wide limits in the total cell count. It is thought that this fact may be attributed to the age of the mouse and possibly to the length of the cord itself (although this latter circumstance is not always true).

These findings provide direct evidence in support of those of Detwiler (1926), who found in his experiments with Ambystoma that the motor cell counts of the two sides of the cord were closely correlated; and that the addition of more muscle fibers by grafting, without providing in any way for the nervous innervation other than that supplied by the host of the grafted tissue, did not change the cell count in the ventral horns of the host, although in some cases the nerves were supplying almost twice as much muscle tissue as they would normally have done had there been no grafted muscle tissue.

Coghill (1913), in his work upon the development of the nervous and myotomic systems in Ambystoma, found that the neurones which establish the earliest contact with the cells of the myotome

are the neurones of the motor cells in the ventral horns of the cord. He also found that there is a distinct correlation between the outgrowth of the ventral horn neurones and the differentiation of the myotome; and that the outgrowth of the ventral neurone is

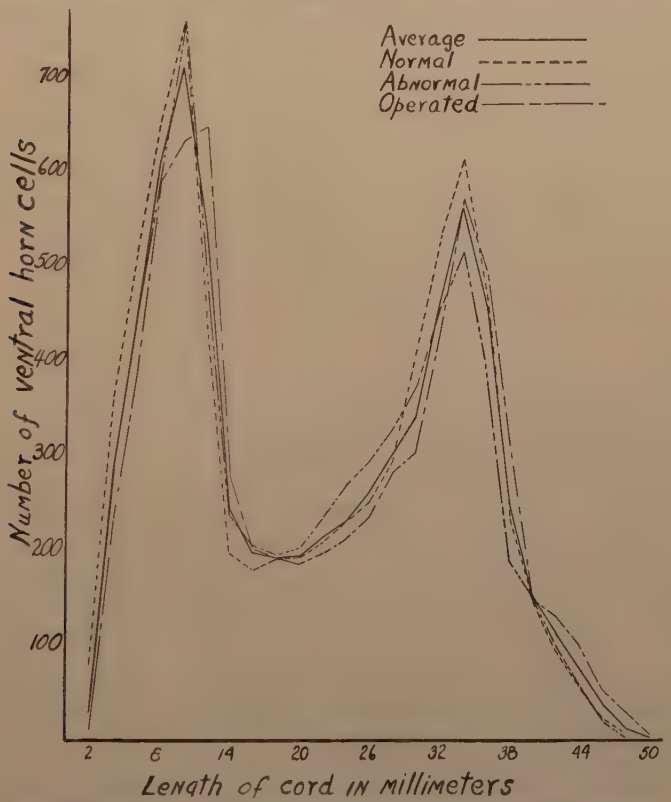

FIG. 60 (Graph II). Curves showing variations in cell counts of various types of cords

coincident with polarization of the muscle cell by the localization of pigment granules in its center.

In addition to this, Coghill concludes that the primary and most fundamental divisions of the vertebrate nervous system are longitudinal and are differentiated upon the basis of unity of function within each division.

From these observations it is evident that, as long as there is any myotomic development at all, there will be a coincident outgrowth of motor neurones from the cord.

In 1909, Shorey, working on the developing chick, amputated the limb buds at an early developmental stage and showed that the non-development of large muscles has an effect upon the cord, but that when any of the muscle remained after the operation, the part of the nerve bundle which grew out to this muscle was considerably out of proportion to the size of the muscle.

It may be inferred from this that in the case of the abnormal feet, the deficiency, if there is any in motor innervation, is not sufficiently large to make itself apparent in the cell count of the cord.

CONCLUSION

We have seen that:

1. Detwiler found no change in the number of motor cells of nerve bundles which supplied more than their normal quota of muscle;

2. Shorey found remnants of muscles to be innervated by nerves which are reduced but little, if any, from their normal size;

3. Coghill found that the smallest myotomic development is accompanied by an approximately normal growth of the peripheral nerve;

4. Our own data show that the relatively small atrophy of muscle in the feet of these abnormal mice is not accompanied by an appreciable deficiency in the cord.

It may be concluded, therefore, that the underlying causes of the leg deformity in the series of mice under investigation is not to be sought in an injury to the spinal motor neurones due to X-ray irradiation.

UNIVERSITY OF MICHIGAN

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A BIOLOGICAL EXAMINATION OF LOON LAKE, GOGEBIC COUNTY, MICHIGAN, WITH SUGGESTIONS FOR INCREASING ITS YIELD OF SMALL-MOUTH BASS (*MICROPTERUS DOLOMIEU*)*

JACOB REIGHARD

IN southeastern Gogebic County, Michigan, there is an area dotted with many lakes (Map 13). The four largest of these and the only ones included in this discussion are Clark, Loon, Whitefish and Crooked. About twenty-two years ago small-mouth black bass (*Micropterus dolomieu* Lacépède) were introduced into the first three of these lakes and bass of good size are still caught in satisfactory numbers in Whitefish. But those taken in Clark and Loon lakes are small and few. Since Clark Lake contains deep-water trout, it affords satisfactory fishing in spite of its relatively poor showing in bass. Since, on the other hand, Loon Lake supports no game fish but bass, this study was made in order to find out what, if anything, could be done to improve the bass fishing in it. I spent the time from August 19 to August 27, 1926, in examining Loon Lake and incidentally gave some time to Whitefish Lake and to a small bog pond just south of Loon Lake in which it had been suggested that bass food might be grown.

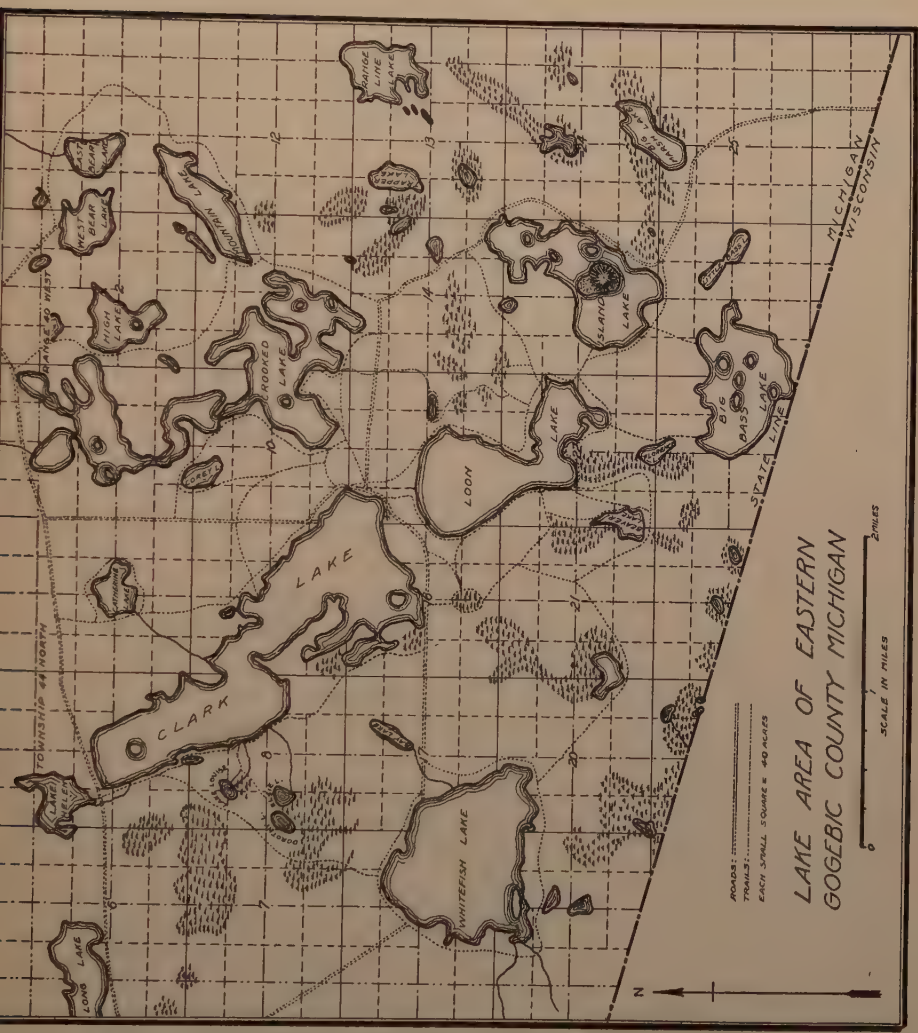
A. LOON LAKE

I. *History, topography, water circulation.*— The lakes of this region were left as water-filled depressions in a sand area when the glaciers retreated. They were at first more numerous and some of them were of greater extent. The invasion of bog vege-

* From the Zoölogical Laboratory of the University of Michigan.

tation has converted certain of the former lakes into bogs, some of which have no open water, while others include small lakes or ponds, the remnant of the open water which formerly occupied the entire bog area. Invasion has also converted shallower parts of some of the existing lakes into bogs. This is notably the case in Loon Lake. Along its north shore an old bog exists, formerly connected with the lake, now cut off by a sand rampart formed originally by floating ice. To judge from the trees on it, the rampart was formed fifty years ago or more. To the south of Loon Lake a large bog (see Map 13) is separated from the lake by a younger rampart, over which water still flows from the bog into the lake. This bog still contains two bodies of open water, Florence Lake and a small pond. In August the surface of its water was above the level of that in Loon Lake as shown by the fact that it was then discharging into Loon Lake. In spring its level must be higher and it must then discharge more water into Loon Lake. It probably has also underground drainage into Loon Lake. Other bogs to the southwest of Loon Lake and east and west of its north end may also drain into it underground. In general, bogs tend to build up their levels and both bogs and sand hills tend to act like sponges and to hold water at a higher level than that of the surrounding ground water. However, the actual levels of the bogs about Loon Lake are not known to me, so that I cannot say with certainty that any of them, except that on the south, drain into the lake.

The topography is such that Loon Lake has a very small drainage-basin from which rain or melting snow may run into it. The amount of rain falling on this small basin is not enough to form permanent inflowing streams, nor is it enough to fill the basin and cause it to spill over the lowest point in its brim in the form of an outflowing stream. After three days of rain there were no rivulets running down the steep forest-covered slope to the north of the lake, although in the bare roadway there was a considerable flow of water. It is, therefore, probable that, under ordinary conditions, rain falling on the slopes of Loon Lake basin does not run off, but percolates through the layer of leaves covering the ground and through the underlying


LAKE AREA OF EASTERN
GOGEBIC COUNTY MICHIGAN
ROADS:
TRAILS:
EACH SMALL SQUARE = 40 ACRES
SCALE IN MILES
0
1
2 MILES
N
MICHIGAN
WISCONSIN
STATE LINE
CLARK LAKE
LOON LAKE
WHITEFISH LAKE
BIG BASS LAKE
SLAND LAKE
CROOKED LAKE
HIGH LAKE
WEST BEAR LAKE
EAST BEAR LAKE
MOUNTAIN LAKE
RANGE LINE LAKE
RANGE 40 WEST
TOWNSHIP 44 NORTH
LONG LAKE
LAKE HELEN
CATHERINE LAKE
CORET L.
LOUISE
DOROTHY L.
GALLEY
FLORENCE
BIG MARSH LAKE
EFFIE BASS L.
EARPER LAKE

MAP 13

sand and reaches the lake by seepage. Probably only when the snow melts in the spring or when rain falls on the frozen ground does water flow over the ground surface into the lake. The surface inflow from at least one bog and probable seepage from other bogs and from sand hills are in that case the sources of the lake's water supply.

According to statements of Mr. T. Kelly of Watersmeet, Clark Lake is thirteen feet higher than Crooked and Loon is four feet higher than Crooked. Underground water is said to well up in considerable quantities in Crooked near the shore of its southwest bay at the point nearest to Clark Lake. This water probably comes from Clark and other water probably flows underground from Loon to Crooked. The higher levels of Clark and Loon lakes, the occurrence of up-flowing ground water in Crooked, the fact that the summer levels are said to fall more in Clark and Loon than in Crooked (more than they should from evaporation alone), all indicate underground circulation of water from Clark and Loon to Crooked. The smaller amount of substances in solution in the water of Loon Lake than in that of Whitefish (and presumably of Crooked) points in the same direction.

Loon is then essentially a *bog lake*, now wholly cut off from its bordering bogs, but still receiving surface inflow from one of them and probably receiving seepage water from other bogs and from the surrounding sand ridges. It appears to discharge underground into Crooked Lake.

II. *Chemical condition of water.*— All data on the physical and chemical conditions in Loon Lake are included in Table I. All tests were made by me in the field and by the methods given in *Standard Methods of Water Analysis of the American Public Health Association*. Hydrogen ion concentrations were determined by the colorimeter method used by Creaser and Brown (1927). In the column headed "acidity" in Table I the *lower numbers* indicate *higher acidity*. Numbers below seven indicate acidity; above seven, alkalinity. In August, 1926, Loon Lake was, therefore, *slightly acid* at the top and somewhat more acid at the bottom. In winter it is probably more acid and in spring still more acid, owing to increased inflow of highly acid bog waters. Three or

four years ago it may have been much more acid than it is now. According to unpublished observation of Professor Paul Welch on similar, but much smaller, acid lakes in the Southern Peninsula of Michigan, acidity has decreased for the past four years. This is thought to be due to the decreased rainfall of those years and the consequent lessened inflow of acid ground water. It is a temporary condition which in this case has brought one of the lakes from high acidity to neutrality. Several years hence, with increased rainfall, these lakes will probably return to their former condition of high acidity. Similar fluctuations in acidity are probable in Loon Lake. Several years ago it may have been much more acid than it now is: several years hence it may again be much more acid.

A second characteristic of Loon Lake water is the *absence of normal carbonates*, carbonates of calcium or magnesium, the former sometimes called carbonate of lime. Normal carbonates do not appear in the table. The carbonate shown in the table is all in the form of *bicarbonate* and its quantity is small (13.2 parts per million). The absence of normal carbonate is due to the small quantity of that substance in the soil through which the water percolates and to the excess of acid in the water. The percolating water contains presumably (not tested) much free carbon dioxide (acid) which combines with the small amount of normal carbonate in the soil and converts it into bicarbonate, but without neutralizing all the acid. As the water enters the lake it contains, therefore, no normal carbonate, but only bicarbonate with an excess of free carbon dioxide. The large amount of free carbon dioxide (26 parts per million) in the bog to the south of the lake, the presence of an excess of that substance and the large amount of oxygen in the lake water, indicate that its acidity is due to free carbon dioxide. The possibility of the occurrence of mineral acids is not excluded.

The result of the lack of normal carbonate is that the water is soft. The numbers in the column "fixed carbon dioxide, c.c. per liter" indicate the degree of hardness. Soft water lakes are those with less than five cubic centimeters of fixed carbon dioxide per liter of water. Loon has 4.9. In contrast

to this Whitefish has 20.6 cubic centimeters per liter of fixed carbon dioxide and is therefore moderately hard and close to the upper limit (22) of hardness in that class.

A third important and favorable characteristic of Loon Lake from the chemical standpoint is that it contains large quantities of oxygen. In the column headed "oxygen, percentage of saturation," it is seen that, at all levels, the water is *supersaturated*, that is, it contains more oxygen than it is possible for fresh water to absorb from the air at these temperatures and at this elevation. As ground and bog waters are, so far as known, deficient in oxygen, Loon Lake can scarcely get its excess supply of that gas from its inflowing waters. The gas is, no doubt, formed in the lake by the action of algae which break up the acid (CO_2) and liberate the oxygen. The supersaturation is greatest at mid-level (16.5 feet), a level at which algae often occur in greatest abundance.

The acidity of the lake is believed to be due primarily to carbon dioxide formed by the decay of bog vegetation and by decay of the leaves covering the ground in the forest. From these sources the acid is carried into the lake, only a part of it being neutralized by normal carbonates in the soil — an excess remaining in the water. As the map indicates, the two acid lakes (Loon and Clark) are those surrounded by bogs, some of which drain into them. They are also the lakes which stand on sand poorest in normal carbonates and therefore least capable of neutralizing the acid. The sand on Loon Lake shore shows no normal carbonate by a crude chemical test. These two acid lakes contrast with Whitefish, which has, perhaps, less contributing bog to form acid and whose shore sand shows by the same test considerable amounts of normal carbonate. There is presumably more acid in a given volume of the entering water of Loon and Clark lakes and less normal carbonate in the soil to neutralize it. On the other hand Whitefish (and probably Crooked, which was not tested) had presumably less acid inflowing water and more normal carbonate in the soil to neutralize it. Birge and Juday (1911) point out the wide variation in fixed carbon dioxide in the soils of Wisconsin and the very small amounts present in the soils of northeastern and northwestern Wisconsin.

Acidity is in general an unfavorable condition for most fish. The subject has been only recently investigated and our knowledge is very meager (Coker, 1925; Jewell and Brown, 1926, and citations; Creaser and Brown, 1927). But it indicates that trout and black suckers thrive in slightly acid waters. In Loon Lake there are reported to be native white suckers and the cisco, which belongs to the trout family. Acid waters are not commonly inhabited by black bass or members of that family. In the case of Loon Lake, however, the high oxygen content is an advantage. Acidity in the presence of high oxygen is much more favorable than acidity with low oxygen, which is the usual condition (Wells, 1913).

III. *Biological Conditions.*— Owing to lack of apparatus no detailed examination was made. I had expected to have Dr. Metzelaar of the State Conservation Commission make such examination with apparatus that he brought with him to Watersmeet and I, therefore, did not myself bring such apparatus. The examination by Dr. Metzelaar proved to be impracticable.

In general, Loon Lake is in a biologically young stage. Ordinarily a lake of this size is fertilized chiefly by soil and by vegetable débris brought into it by inflowing streams and to a smaller extent by leaves blown into it. Out of these materials it develops a bottom soil or muck and from them certain necessary chemical substances go into solution in the water. Other such substances go into solution in the water before it reaches the lake, their kind depending on the *nature* of the soil and their quantity in it, on their *solubility*, and on the *distance* traversed by the water over or through the soil or rock.

Without inflowing streams Loon Lake has acquired practically no muck on its bottom. Such as it has comes from inblown leaves. Owing to this fact and to the poverty of the soil through which the waters percolate to enter it, it has remained chemically poor. In the small bay which connects with the south end of the lake on the east there is a thin deposit of muck, perhaps one tenth of an inch thick, over sand and stones. Elsewhere there is very little muck unless it be in the deepest water, where I was unable to examine the bottom. In the bay referred to there was evidence that

suckers were feeding on the meager muck supply. The poverty of the lake in muck bottom and in chemicals in solution prevents its supporting any considerable growth of plants. I saw only a few small bulrushes, some seven-angled pipeworts (*Eriocaulon septangulare*) and a small patch of spatterdock. The latter two were in the bay referred to.

There is no evidence of the existence of mussels or snails in the lake, nor of crayfish. All these require normal carbonates and none of them are known to occur in acid waters, except the mussels (or clams) and they occur rarely. Shrimp introduced from New York State have not since been seen.

IV. *Fish.*— Common suckers (*Catostomus commersonnii*) and ciscos (*Leucichthys sp.*) are reported and one miller's thumb (*Cottus*) was found in a bass stomach. Only a single specimen of small-mouth bass was obtained from this lake — but twenty-five specimens from Whitefish Lake were examined. Details for the Loon Lake specimen and for fifteen of the Whitefish Lake specimens are included in Table II. The stomachs of twelve of these sixteen fish were empty, as were those of ten additional small-mouth from Whitefish Lake not included in the table. Of the Whitefish Lake bass, one contained two crayfish, one a small fish too far digested to identify, but probably cisco, one a small leopard frog. The Loon Lake specimen contained a small fish (miller's thumb), an immature dragon-fly and several caddis worms in cases of coarse sand. The intestine was filled for two inches with coarse sand, like that in the caddis worm cases. This fish was evidently feeding on a bottom of coarse sand and in rather deep water. This indicates little if any muck on the bottom in deep water.

The *sizes*, *weights*, and *ages* of the Whitefish and Loon bass are shown in Table II. Ages were determined by Dr. John Van Oosten from scales collected by me.

There is little record of the weight of small-mouth bass of different lengths and none of weights at different ages. The maximum weight is stated by Jordan to be 5 pounds, but I have learned of specimens reaching the weight of $7\frac{1}{4}$ and $7\frac{3}{4}$ pounds, the former from a lake of the approximate size of White-

fish. In general, other conditions being the same, weight and length of fish depend on the size of the waters inhabited and the abundance of food. Larger fish of any kind are to be expected in larger waters. All the Whitefish Lake (and Loon Lake) bass examined are *very old*, nine to thirteen years. The oldest and heaviest (No. 15) weighed a little less than three pounds. From waters of this size with abundant food the bass might be expected to reach from one and a half times to twice this weight at this age. Such a statement must, however, be regarded as largely conjectural, for we know nothing of the relation between age and weight of this species. The cause of underweight is discussed elsewhere.

The single Loon Lake bass measured 14.4 inches and weighed 21 oz. The average length of numbers 5 and 8 from Whitefish Lake was also 14.4 inches and their average weight was 27.25 oz. So far as can be judged from a single specimen, the Loon Lake bass are 30 per cent less in weight than those of equal length and age from Whitefish. There is undoubtedly more bass food in Whitefish Lake, and its waters are alkaline.

The data of Table II are rearranged in Table III to show the relation of length to weight in the Whitefish Lake bass. In general the weights increase with lengths. The weights and lengths are averaged in the right-hand part of Table III. In general, fish in their fifteenth inch average 10.5 years old and weigh 27.3 oz. Fish in their sixteenth inch average 10.4 years old and weigh 35.3 oz. Fish in the seventeenth inch are from 11 to 12 years old and weigh 39.7 oz. The single fish in the eighteenth inch was 13 years old and weighed 47 oz.

In Table IV the data for the same fifteen fish are arranged according to age, to show increase of length and weight with age.

Thus from the ninth to the thirteenth year about 2.45 inches is added to the length and about 11 oz. to the weight. Not much attention should be paid to single specimens such as those representing the ninth, twelfth and thirteenth years. These may have been, and without much doubt they were, large individuals for their age. More specimens would be needed to know the average length and weight at nine, twelve, and thirteen years. But if we

compare the tenth and eleventh years, the average weights and lengths are practically identical and *it is indicated that on the average the fish have practically stopped growing.* Probably after its ninth year the average bass is unable to get enough food in this lake to increase its weight.

It should be noted further that fish of the same age may differ greatly. Thus No. 13, ten years old, is about two inches shorter than No. 14, also ten years old, and weighs about 10 oz. less.

V. *Parasites of small-mouth bass.*— Dr. A. E. Woodhead, of the Department of Zoölogy of the University of Michigan, kindly examined the viscera of three specimens. He reported from the ovary of one "a cestode (immature), presumably *Protocephalus ambloplites.* . . . The fish was evidently sterile as eggs had not been discharged and were being absorbed." A mature cestode was obtained from the intestine and also two males of *Spinitectus gracilis* and one female with the ovaries full of eggs. Numerous encysted forms "appear to be nematodes." The caeca were very full of Acanthocephalus.

All the twenty-six specimens examined by me in the field were parasitized and all but two or three were very heavily parasitized. Parasites are usual in fish and the presence of these does not preclude the use of the bass as food. None of them are parasites that infest man and they do not occur in the parts of the fish that are eaten. Their importance lies in the heaviness of the infestation and in its effect on the fish. In all but three specimens the viscera were bound together in a single mass because of the irritation tissue produced by the parasites and were adherent to the lining of the body cavity. In cleaning the fish it requires much force to pull out the visceral mass and the body cavity lining comes with it.

The difference in weight of these bass when of the same age and length may well be due, in part, to different degrees of parasitic infestation. In Table III, Nos. 8, 4, and 15 were recorded as less heavily parasitized than the others. No. 4 is the heaviest fish in the seventeenth inch and No. 15 is also a relatively heavy fish.

The most serious condition induced by the parasites is *sterility.*

In the three specimens brought to Ann Arbor the ovaries were infested by a tapeworm, which is known to render bass sterile. The ovaries of these three fish (one from Loon Lake, two from Whitefish) still contained the eggs that should have been laid last spring and these were being resorbed.

Examination of the sexual organs of the other thirteen bass listed in the table showed them to be in the same condition so far as could be told with the naked eye. The sexual organs were so much infested that it was often uncertain whether a given fish was male or female. Probably all fish of this age are sterile. Whether there are younger bass in Whitefish and Loon lakes, so little parasitized as to be capable of breeding, I do not know. The finding of breeding beds or small bass would determine the point, but this seems to me unlikely in view of the condition of the fish examined.

B. LOON LAKE BOG POND

This pond, situated in the bog south of Loon Lake and a few rods from the lake shore, has a maximum depth of about fifteen feet and an area of perhaps half an acre. Its waters, at a depth of between six and seven feet, and also at the surface (on a different date), are strongly acid (4.4 and 4.6, Table I). Compared to Loon Lake the acidity is very much greater than appears from comparison of the pH numbers 4.4 and 6.4 or 6.8. At the six- to seven-foot depth this pond contains only 0.7 c.c. per liter of oxygen or 11.3 per cent of saturation, and at the same depth 26 parts per million of free carbon dioxide. The combination of high acidity, very low oxygen and much carbon dioxide is extremely poisonous to fish. Nothing living was found in the pond, except some green algae mats about the edge and bacteria in the free water.

It had been suggested that this pond might be used for rearing bass food. *But the pond will not support any form of fish food in its present condition and, owing to the constant ingress of bog water similar to that in the pond, it is impracticable to improve its condition.*

C. WHITEFISH LAKE

Its waters are alkaline (pH 7.8) with about four times as much bicarbonate (55.4) as those of Loon Lake (13.2) and with about four times the hardness. It is good bass water.

D. METHODS OF INCREASING THE BASS SUPPLY OF LOON LAKE

I. *By chemical treatment.*— A fundamental remedy is to enrich the lake and correct its acidity by adding fertilizing materials and normal carbonates. This is the practice in Europe with smaller bodies of water and has been successful with some much smaller lakes in Michigan. Treatment with normal carbonates is also usual in the case of acid soils.

The essential thing is to get soil into the lake for the growth of plants. This may be taken from any available source and dumped upon the ice or into shallow water. There is probably material enough in the neighborhood. Bog soil could be used, but should first be treated with lime. Inorganic fertilizers may be mixed with it.

As nearly as can be determined from the map, the area of Loon Lake is 380 acres, that of Clark, 810 acres. The cost of treatment should not be much greater than that of liming an equal area of acid soil and then fertilizing it as though it were barren. But I do not find in the literature any record of an attempt having been made at the chemical treatment of a lake of this size.

By this method it should be possible entirely to control Loon Lake and make it normally productive in bass of good weight and in bass foods. It would be necessary to have it chemically examined from time to time to supplement the treatment in case the water should again tend to approach acidity on account of the inflow of bog water or in case the growth of plants reduced the supply of introduced fertilizers. It should also be chemically checked to control its alkalinity. Too high alkalinity would be as unfavorable as acidity. The work of fertilization could be done slowly over a term of years by beginning with the more protected waters, such as the bay at the south end of the lake. Plants could be put in as soil was added and would tend to spread.

It has been suggested that wild rice might thrive in Loon Lake, or that introduced crayfish might live and multiply there. I have seen wild rice growing only where there was a good deposit of bottom muck. It seems, therefore, useless to introduce it into Loon Lake until soil has first been added. So far as known, crayfish do not occur in acid waters and it is unlikely that any of the various species would live in Loon Lake. They occur in the somewhat alkaline waters of Whitefish Lake and might be transferred to Loon Lake and kept under observation to see whether they would adapt themselves to its acid water. There is little likelihood that they would.

II. *By the use of Loon Lake as a holding basin for introduced bass.*— It is entirely possible to introduce a new stock of small-mouth bass into Loon Lake and to feed them on natural food from artificial ponds to be constructed near it.

Before considering the practical details of such a procedure, it is necessary to discuss the relation of the size of small-mouth bass to the conditions obtaining in Loon Lake. The fundamental adverse conditions are *acidity* and *scarceness of food.* It might seem that bass, if abundantly fed and not diseased, would reach their maximum weight in any water. But it is possible, indeed probable, that acidity in itself retards growth and limits the final weight attained, no matter how much food is supplied. That is, it is possible or probable that bass in Loon Lake as it now is would not reach maximum weight no matter how much food is given them. There are but few published investigations on the effect of acidity on growth-rate (see citations in papers listed) and none of these deal with fish.[1] None of them deal with natural waters. It is my opinion, based on such evidence as we have, that bass will not attain to full weight in the acid waters of Loon Lake even if abundantly fed, but what weight they will reach at a given age can be known only from further research. If my information is correct that the bass in Clark Lake reach larger

[1] The following deal with invertebrates or plants: Loeb (cited by Moore, Roaf and Whitley); Moore, Roaf and Whitley, *Proc. Roy. Soc.*, B LXXVII, 102; Moore, Roaf and Knowles, *Bioch. Journ.*, III, 279; Labbé, C. R., *Acad. Sci. Paris*, CLXXVI, 1423. They show retardation of growth-rate by acidity, acceleration by alkalinity.

size than those in Loon Lake, this may be due to greater total quantity of bass food in Clark Lake, because of its larger size. This indicates that, if well fed, bass in Loon Lake in its present condition would reach larger size than they have hitherto reached in either Loon or Clark lake.

III. *Procedure, in the order of time, in the use of Loon Lake as a holding basin.*— (*a*) A pond of four acres or less may be constructed somewhere on the shore of Loon Lake and used for breeding bass food. Its surface should be somewhat above the level of Loon Lake, so that it may be drained into it. It would be best if its bottom were above the level of Loon Lake surface, so that it could be entirely drained if necessary. It should be shallow, two feet in most parts, with deeper holes, 6 to 8 feet, in which minnows could winter.

Water to fill a pond and make up for loss by seepage and evaporation may be piped from Clark Lake, and that the more readily if the pond is constructed in the bog bordering the north end of the lake and very near Clark Lake. In this matter I consulted the late Mr. Dwight Lydell of Comstock Park, Michigan, a practical pond expert of long experience. He estimates that such a pond or ponds would require about eight hundred gallons per day of running water. In the course of seven months (the presumable open season) this would withdraw about 25,000 cubic feet of water and lower Clark Lake only 0.0066 foot. If one hundred times that quantity were used Clark Lake would be lowered only about three quarters of an inch and would regain its original level each year.

The water from Clark Lake might go first to a basin or pool containing broken limestone to neutralize the acid and should then be conducted to the pond and from there to Loon Lake. As there is nine feet difference in level between the two lakes no pumping would be necessary.

COST OF POND CONSTRUCTION AND MAINTENANCE AS ESTIMATED BY MR. LYDELL

Estimated cost of a four-acre pond, complete, fertilized, and stocked with plants, minnows, etc.	$6000.00
Supervision of pond construction	200.00
Food for the fish, etc., in the pond (600 lb. of clam meal, annually, @ 12½¢.)	75.00
Man to care for pond and feed the bass in Loon Lake	?
Rough total,	$6275.00

Such pond or ponds should be practically self-sustaining. They would require occasional examination by a scientific consultant and occasional addition of fertilizers. Assuming the pond to be put into operation in the spring, it should furnish a supply of bass food by the next fall.

(*b*) Bass could be raised on the premises, but I learn that this fall (1926) for the first time small-mouth bass may be purchased from a commercial concern.[2] When they are furnished in the fall, they are five or six months old and three to four inches long. Introduced at that time the bass would hibernate and feeding could begin the next spring.

I am told that these small bass are free from parasites. They would probably acquire them in the lake and be made sterile. In that case new stock should be added from time to time. If they did not acquire the parasites, the original stock would perpetuate itself. Whitefish Lake should probably also be restocked, certainly so if it now contains only a few small bass or none.

SUMMARY

Loon Lake

1. Loon Lake, with an area of about 380 acres and a maximum depth of about 40 feet, lies on sand on the top of the divide between Mississippi and St. Lawrence drainage basin in eastern Gogebic County, Michigan, along with Clark, Crooked and Whitefish lakes.

[2] The Wolverine Bass Hatcheries, 255 Houseman Building, Grand Rapids, Michigan.

2. Loon Lake has neither surface outlet nor surface inlet. Surface water drains into it from a bog on the south. Underground water probably reaches it from other bogs and from Clark Lake, nine feet higher than Loon. It probably discharges underground to Crooked Lake, which is four feet lower.

3. In August, 1926, Loon Lake had the following chemical characteristics: free carbon dioxide, 0.5 p.p.m. at surface to 2.0 p.p.m. at 11 meters; fixed carbon dioxide, 4.9 c. c. per liter; carbonic acid (CO_3), 13.2 p.p.m.; oxygen, 107 per cent of saturation at the surface in the day time, increasing to 118 per cent at 5 meters and decreasing to 108 per cent at 11 meters (bottom at 12 meters); hydrogen ion concentration, pH 6.4 at bottom to pH 6.8 at top. It is a *slightly acid, soft water* lake.

4. Late August temperatures graded from 19.7° C. at the surface to 18.2° C. at 11 meters, in 12 meters of water.

5. Water in a small bog pond which discharges into Loon Lake on the south showed a hydrogen ion concentration of pH 4.4 to 4.6 with 26 p.p.m. of free carbon dioxide and an oxygen content of 11.3 per cent of saturation. It is probable that the acidity of Loon Lake is due wholly to carbon dioxide contained, in part, in inflowing surface bog waters and, in part, in seepage waters.

6. The low content of Loon Lake water in carbonate (13.2 p.p.m. CO_3) is presumably due to the small amount of carbonates in the soil, which is largely siliceous sand.

7. The high oxygen content is attributed to the availability of free carbon dioxide and to the assumed presence of plankton algae. The distribution of the oxygen with maximum values at mid-depth supports this interpretation.

8. There are no thick muck deposits visible in the shallower water of Loon Lake. Deposits observed do not exceed one eighth to one quarter of an inch, but are probably heavier in deeper water.

9. As was to have been expected from its chemical characteristics and lack of bottom muck, Loon Lake contains only a very sparse growth of macroscopic aquatic plants — bulrush, spatterdock and pipewort, but no pond-weeds or Chara.

10. Introduced small-mouth bass and Cottus were collected

in Loon Lake and cisco and suckers were reported. No molluscs or crayfish were found.

11. The single small-mouth bass taken in Loon Lake was under size and under weight for its age (see tables) and 30 per cent less in size and weight than bass of the same age from Whitefish Lake. It was heavily parasitized.

Whitefish Lake

12. With 20.6 c.c. per liter of fixed carbon dioxide Whitefish Lake is moderately hard. Its hydrogen ion concentration was pH 7.8 at the surface (alkaline).

13. Whitefish contains crayfish and molluscs and the usual pond-weeds and other aquatics.

14. Fifteen small-mouth bass obtained from Whitefish Lake varied in age from 9 to 13 years, in length from 14 to 17¾ inches and in weight from 26 to 47 oz. They are believed to be under size and under weight for their age, but there are no exact published records for comparison.

15. All Whitefish Lake bass examined were heavily parasitized and all are believed to have been rendered sterile by an immature Protocephalus in the ovaries.

Suggestions for rendering Loon Lake a satisfactory small-mouth bass lake

16. Loon Lake may be made alkaline and fertile by chemical treatment similar to that employed in fertilizing barren, acid soil and small fish ponds. It would then support the plants and animals usual in a fertile lake, including small-mouth bass of normal size and weight.

17. The small size of small-mouth bass in Loon Lake and their fewness may be due to one or more of the following factors: (1) insufficient food, (2) acidity of the water acting to retard growth, or (3) parasitism. These factors must be considered in any plan which does not involve the chemical enrichment of the lake.

18. Since the bass of Loon Lake (and Whitefish) are rendered sterile by parasites, a fresh non-parasitized stock of fish should

be introduced from time to time. They may or may not become sterile. If they do not, the introduction of non-parasitized stock could be discontinued.

19. Bass food may be raised in an artificial pond or ponds constructed near Loon Lake and such food may be introduced into Loon Lake, which would then remain in its present condition chemically and serve merely as a holding basin for bass. The small bog-pond south of Loon Lake is entirely unsuited for rearing bass food.

20. The effect of acidity of the medium on growth-rate of bony fishes is not known and there can be no assurance that bass held in acid water and abundantly fed from outside sources would show a normal growth-rate. They probably would not.

DISCUSSION

I call attention to our lack of published data on the growth-rate of small-mouth bass. I have been able to find in the literature only general statements as to the weight reached by the species or by individual specimens. It should be easy for one summering on small-mouth bass waters to collect data bearing on this problem. The bass caught by fishermen should be weighed and measured and a few scales preserved from the middle of the side of each one. Bass under legal size should also be obtained and similarly treated. The value of the field data would be increased if the viscera of each specimen were preserved for use in determining sex, food, and character and extent of parasitisation. Anyone wishing to collect data and material of this sort could, if necessary, obtain detailed technical instructions from the Division of Fishes of the Museum of Zoölogy of the University of Michigan, or from the Michigan State Conservation Commission. The study of such material would reveal the growth-rate of small-mouth bass. With accumulation of data, comparison of growth-rate of bass in waters of different size and of different chemical and biological character would be possible. Light might then be thrown on the relation of growth-rate to acidity of the medium. Doubtless the same statements apply to most of our fresh-water fishes.

The relation between acidity of the medium and growth-rate of bass or other fresh-water fishes is also in need of experimental study in both field and laboratory. It is indicated that acidity of natural waters reduces growth-rate, but beyond this lies the further question of whether the acidity acts directly on the fish to retard growth, or whether it operates indirectly by reducing the food supply.

University of Michigan

TABLE

PHYSICAL AND CHEMICAL DATA ON TWO LAKES AND A LOON

Depths		Temperatures of water Aug. 23		Dissolved oxygen		
Meters	Feet	Centigrade	Fahrenheit	Parts per million	Percentage of saturation	C. c. per liter
0	0	19.7	67.5			
1	3.3	19.5	67.3	9(20.5°C)	107	6.3
2	6.6	19.5	67.3	9.8(19°C)	113	6.9
3	9.9	19.5	67.3			
4	13.2	19.5	67.3			
5	16.5	19.4	66.9	9.9(20.5°C)	118	6.9
6	19.8	19.4	66.9			
7	23.1	19	66.2			
8	26.4	19	66.2			
9	29.7	19	66.2			
10	33	18.8	65.8	9.4(20.5°C)	113	6.6
11	36.3	18.2	64.8	8.4(19.5°C)	108	5.9
Bottom at 12 meters	39.9					
LOON LAKE						
0	0					
2	6.6	16.75	62.2	1(16.75°C)	11.3	0.7
Bottom at 15 ft.						
WHITEFISH						
0	0					

NOTES: (1) Percentage of saturation of dissolved oxygen is calculated for the elevation of 1,800 ft. (2) None of the waters showed any trace of normal carbonates, i.e. they were negative to phenophthalein. Sand from Loon Lake shore showed no evolution of gas when heated with strong acid. That from Whitefish Lake showed gas bubbles under the action of strong

No. I

POND IN GOGEBIC COUNTY, MICHIGAN, AUGUST, 1926

LAKE

Free carbon dioxide parts per million	Acidity pH scale	Carbonate, CO_3, p.p.m. (Methyl orange)	Fixed carbon dioxide, CO_2		Dates of oxygen and pH determinations August, 1926
			Parts per million	C. c. per liter	
0.5 (?)	6.8 (acid)	13.2	9.7	4.9	19
					23
					21
1.5	6.5				23
2	6.4 (acid)				23

BOG POND

	4.4 (acid)				21
26	4.6 (acid)	15.4	11.6	5.9	24

LAKE

1	7.8	55.4			

acid, thus indicating carbonates in the Whitefish sand, none in Loon Lake sand. (3) Temperatures in brackets following dissolved oxygen values in parts per million are those of the samples used and do not necessarily agree with those in the column headed "temperatures." Temperatures were variable by location.

TABLE II

DATA ON SMALL-MOUTH BASS, *MICROPTERUS DOLOMIEU*, FROM GOGEBIC CO., MICHIGAN

WHITEFISH LAKE: August 21, 1926

Serial No.	Sex	Length in inches	Weight in oz.	Stomach contents	Parasites	Year of life
1	?	15.2	33	empty	badly parasitized	11th
2	?	15.1	34	empty	no record	10th
3	F	15.6	37	empty	badly parasitized	10th
4	F	16	45.5	empty	not badly parasitized	12th
5	F	14.8	28.5	empty	badly parasitized	10th
6	M	15.9	35.5	empty	no record	11th
7	M	15.3	36	empty	no record	9th
8	?	14	26	one 4″ crayfish	not badly parasitized	11th
9	M	16.4	36.5	empty	badly parasitized	11th or 12th
10	F	15.4	34	empty	badly parasitized	11th
11	?	15.3	39	one 4″ fish, probably cisco	badly parasitized	10th
12	M	15.1	34	empty	parasitized	12th
13	F	14.7	27.5	empty	badly parasitized	10th(?)
14	?	16.6	37	one 5″ leopard frog	parasitized	10th
15	?	17.75	47	empty	not badly parasitized	13th
LOON LAKE: August 23, 1926						
16		14.4	21	one small fish (Cottus) 2″ long, one dragon fly nymph (Macromia). Several caddis worms in sand cases. Intestine contained much coarse sand	badly parasitized	10th

NOTE: LENGTHS measured with steel tape along the curvature of the body between the tip of snout with mouth closed and the caudal margin of the last lateral line scale. WEIGHTS taken with a Chatillon spring balance graduated in ounces and weighing to four pounds. Readings to nearest half-ounce. AGES determined from scales by Dr. John Van Oosten.

TABLE III

DATA OF TABLE II REARRANGED

Specimens arranged serially by length				Specimens grouped by inches			
No.	Length in inches	Weight oz.	Age	Range in length	Av. length	Av. weight	Av. age
*8	14	26	11	15th inch (14–14.9) (3 specimens)	14.5	27.3	10.5
13	14.7	27.5	10 (?)				
5	14.8	28.5	10				
2	15.1	34	10	16th inch (15.1–15.9) (8 specimens)	15.36	35.3	10.4
12	15.1	34	12				
1	15.2	33	11				
11	15.35	39	10				
7	15.3	36	9				
10	15.4	34	11				
3	15.6	37	10				
6	15.9	35.5	11				
*4	16	45.5	12	17th inch (16–16.6) (3 specimens)	16.33	39.7	11–11.3
9	16.4	36.5	11–12				
14	16.6	37	10				
*15	17.75	47	13	17.75 (1 specimen)	17.75	47	13

* Fish not as badly parasitized as the others

TABLE IV

DATA OF FIRST FOUR COLUMNS OF TABLE III REARRANGED ACCORDING TO AGE OF FISH TO SHOW RELATION BETWEEN AGE AND LENGTH AND WEIGHT

Year of life	Serial No. of specimens	Length in inches	Weight oz.	Av. length inches	Av. weight oz.
9 (1)	7	15.3	36	15.3	36
10 (6)	13	14.7	27.5	15.35	33.83
	5	14.8	28.5		
	2	15.1	34		
	11	15.3	39		
	3	15.6	37		
	14	16.6	37		
11 (5)	8	14	26	15.38	33
	1	15.2	33		
	10	15.4	34		
	6	15.9	35.5		
	9	16.4	36.5		
12 (2)	4	16	45.5	16	45.5
13 (1)	15	17.75	47	17.75	47

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THE EFFECT OF ARBACIA EGG-SECRETION ON THE DIVISION RATE OF PARAMECIA

ALVALYN E. WOODWARD

IF newly-shed, unfertilized Echinoderm eggs are allowed to stand in sea-water for half an hour or more, they will secrete an appreciable amount of certain substances into that water. This was noted by F. R. Lillie and O. C. Glaser, independently, in 1912. Their original observations were on the eggs of the sea urchin, *Arbacia punctulata*, and the starfish, *Asterias forbesii*. Lillie's interest was focused upon the effects of the egg-secretions on sperm, while Glaser noted that they produced parthenogenetic development of fresh, unfertilized eggs. Since then, many studies have been made on the properties of these substances, and many species and phyla have been found to produce them. This is not the place, however, to review the literature.

Since one of the substances in these secretions initiates development in eggs, it seemed possible that it might stimulate cell-division in Paramecia, so the present investigation was undertaken. If the secretions are preserved by adding 0.5 per cent chloroform, they retain their effectiveness as parthenogenetic agents for a number of years, as the writer showed in experiments on the eggs of *Nereis limbata* (1921). The parthenogenetic substance, lipolysin, can also be precipitated (Woodward, 1918; Glaser, 1921) and so preserved.

In order that the results might be comparable, three or four series of experiments were carried on simultaneously with Paramecia raised from a single individual isolated from a stock laboratory culture. Each series was carried on in quadruplicate with animals from the same line, and ten unrelated lines were used, making forty repetitions of the work. A single Paramecium was placed in six drops of culture medium in a hollow-ground slide, which was then kept in a moist chamber. The latter was prepared

by putting about half an inch of wet sterilized sand in the bottom of a nine-inch culture dish. Microscopic slides placed on edge in the sand formed supports for the culture slides. In these dishes, the air was saturated, and no observable evaporation from the culture slides occurred. Every second day the number of Paramecia on each slide was noted, and one individual transferred to fresh medium.

In the control series A, the Paramecia were raised in a stock nutrient solution made by boiling one gram of timothy hay and a bread crumb in tap-water, then filtering and making up the filtrate to 200 c. c. with tap-water. This was kept sterile and used for a month or more. A second control, B, was made by adding 0.5 per cent sea-water to the stock nutrient, to make the salt content and pH comparable to C and D. This amount of sea-water was chosen after experimenting with different strengths. The culture medium for the first experimental series, C, was made by adding 0.523 per cent Arbacia egg-secretion to the stock nutrient solution. This inconvenient percentage was necessary because, as Glaser had found, the egg-secretions are less alkaline and less salt than sea-water. Since this secretion had been preserved with chloroform, it was thoroughly aërated before using. For series D, an amount of lipolysin (the precipitated parthenogenetic agent) about the size of a pinhead was disolved in 10 c. c. sea-water, and 0.5 per cent of this added to the hay infusion. Colorimetric tests showed that solutions B, C, and D had the same pH and were slightly more alkaline than A. A few experiments in which the pH varied had to be discarded.

The results are most easily seen in the accompanying charts (Fig. 61), which are typical of all experiments where the pH was properly controlled. The dates are plotted on the horizontal axis, and the numbers of protozoa from three slides of the same line are on the vertical axis. It will be noted that the rate of cell-division was maintained for a short time at a higher level in B than A, but that the Paramecia soon died off in solution B. In experiments C (with egg-secretion) and D (with lipolysin), the rate of cell-division was initially higher than in the controls. Then followed a period of depression, which, however, was not so

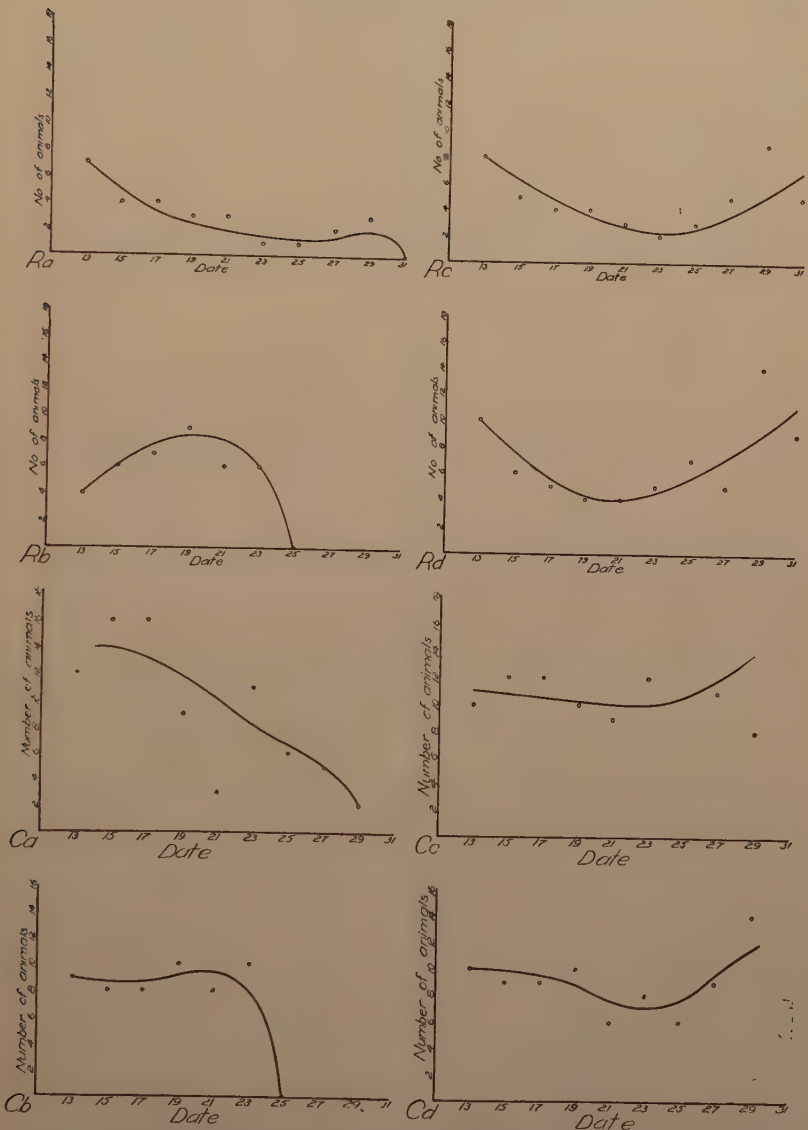

FIG. 61. Experiment III: The number of animals found each day is represented in lines *R* and *C*. On the left are controls; on the right, the cultures to which egg-secretion was added

marked as in the controls; and which, in turn, was followed by an increase in division rate. Besides dividing more rapidly, the Paramecia grown in egg-secretion were considerably larger than the controls.

More conclusive experiments in which the number of bacteria is controlled are now under way at Harvard. It looks, however, as though lipolysin, which is non-specific in causing development of unfertilized eggs, also stimulates cell-division in Paramecia.

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